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Cover photograph: California sea lion (left) and Steller sea lion (right) (photo by G. Ellis).

Canadian Special Publication of Fisheries and Aquatic Sciences 77

Status of the Steller Sea Lion (*Eumetopias jubatus*) and California Sea Lion (*Zalophus californianus*) in British Columbia

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Abstract

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Aerial censuses were undertaken for Steller sea lions (*Eumetopias jubatus*) and California sea lions (*Zalophus californianus*) during 1971–84, and a review was made of published and unpublished data on numbers seen and numbers killed since 1913. These data were used to describe the location of haulout sites, season of occupation at haulout sites, regional movement patterns, and trends in numbers seen for each species during this century. Steller sea lions occupied eight rookeries, 15 year-round haulouts, and at least 50 winter haulouts and winter rafting areas. Rookeries were occupied throughout the year with a peak in numbers during July. Year-round haulouts showed no marked seasonal variation in number of individuals seen. Winter sites were occupied primarily in winter, although sometimes during August–May. The trend in numbers of Steller sea lions on a rookery depended mainly upon the size of kills made at the rookery. A reexamination of early census data suggests that a total of 11 000–14 000 animals of all ages were seen on rookeries in 1913, about 1 000–5 000 more than previously believed. Kills during 1913–68 resulted in a series of population declines. By 1971–82, numbers averaged only 3 800 on rookeries and 1 900 on year-round haulouts. Most animals appeared to move seasonally between local rookeries and winter sites, with some immigration and emigration likely.

The California sea lion was seen during September–May, primarily off Vancouver Island. Only adult and subadult males were present. The species was rare between the late 1800's and the 1960's, and was confined to southwestern Vancouver Island. In the 1970's, the range expanded into waters off southeastern Vancouver Island. Total numbers increased from about 500 animals in 1972 to 4 500 in 1984, with most of the increase taking place since 1980.

Résumé

BIGG, M. A. 1985. Status of the Steller sea lion (*Eumetopias jubatus*) and California sea lion (*Zalophus californianus*) in British Columbia. Can. Spec. Publ. Fish. Aquat. Sci. 77: 20 p.

De 1971 à 1984, on a effectué des recensements aériens de l'otarie de Steller (*Eumetopias jubatus*) et de l'otarie de Californie (*Zalophus californianus*); de plus, on a fait une étude documentaire des données publiées et inédites sur le nombre observé et tué depuis 1913. Ces données ont servi à la description des emplacements terrestres occupés, de la période d'occupation de ces emplacements, des régimes de déplacement local et des tendances du nombre d'individus de chaque espèce observés au cours du présent siècle. L'otarie de Steller fréquentait huit colonies, 15 emplacements terrestres toute l'année et au moins 50 emplacements à terre et sur la glace en hiver. Les colonies étaient occupées pendant toute l'année avec une pointe d'abondance en juillet. Dans les emplacements terrestres utilisés toute l'année, aucune variation saisonnière marquée du nombre d'individus n'a été observée. Les emplacements d'hiver ont surtout été fréquentés pendant cette saison, quoique à l'occasion de août à mai. La tendance du nombre d'otaries de Steller observées dans une colonie dépendait principalement de l'importance de la chasse dirigée vers cette colonie. Un nouvel examen des premières données de recensement porte à croire qu'un total de 11 000 à 14 000 animaux de tous âges ont été observés dans les colonies en 1913, soit à peu près 1 000–5 000 de plus qu'on ne le croyait antérieurement. De 1913 à 1968, la chasse a entraîné une série de déclins de la population. Entre 1971 et 1982, le nombre s'élevait en moyenne à 3 800 dans les colonies et à 1 900 dans les emplacements terrestres utilisés toute l'année. La plupart des animaux semblait migrer annuellement entre les colonies locales et les emplacements d'hiver; une certaine immigration et émigration étaient probables.

L'otarie de Californie a été observée de septembre à mai principalement au large de l'île Vancouver: seuls des adultes et des subadultes étaient présents. De la fin des années 1800 à la fin des années 1960, l'espèce était rare et ne fréquentait que les eaux au sud-ouest de l'île Vancouver. Dans les années 1970, l'aire de répartition s'est étendue dans les eaux hauturières du sud-est de l'île. Le nombre total est passé d'environ 500 animaux en 1972 à 4 500 en 1984; la plus forte augmentation a eu lieu depuis 1980.

Introduction

Two species of sea lion inhabit the coastal waters of the North Pacific Ocean, the Steller sea lion (*Eumetopias jubatus*) and California sea lion (*Zalophus californianus*) (Scheffer 1958; King 1983). Steller sea lions are found from California to the Bering Sea and Japan, and breed throughout their range. Most California sea lions breed in Mexico and California, with a nonbreeding range northward to British Columbia. Small populations are also found on the Galapagos Islands, and off Japan, although the latter population may be extinct. Both species have been hunted throughout their range largely because of the damage which they cause to commercial fish and fishing gear, but also for commercial purposes.

In British Columbia, long-standing complaints about Steller sea lions come mainly from salmon, herring, and halibut fishermen. Fisheries agencies of the Canadian government responded with population control programs that extended from 1913 to 1968. These programs involved bounties, organized kills, and commercial takes for meat, blubber, and hides. During this time, few California sea lions were seen in British Columbia, and the species was not considered a nuisance. In 1970, both species were protected in British Columbia under the Canadian federal *Fisheries Act*. Since the early 1970's, herring, squid, and cod fishermen have complained about an increase in number, and expansion in the range of California sea lions off Vancouver Island, and about increased numbers of Steller sea lions there.

Studies on the Steller sea lion in British Columbia have concentrated on determining numbers, distribution, movements, and behaviour. Pike and Maxwell (1958) did the most recent assessment of numbers and the effect of the herd reduction programs. These authors reported 11 000–12 000 animals were present on rookeries and nonbreeding sites during 1956–57. This figure was similar to that given by Newcombe and Newcombe (1914), who reported 11,000 in 1913. Pike and Maxwell (1958) noted that kills eliminated breeding on the Virgin Rocks, Pearl Rocks, and Watch Rock by the 1930's. Between 1958 and 1968, another herd reduction program was undertaken in which the species was killed on most rookeries and nonbreeding sites. Pike (1966) undertook field studies on the animals that were killed. Other studies on general biology of this species were by Pike (1961), Smith (1972), Harestad and Fisher (1975), Harestad (1977, 1978), Edie (1977), Brenton (1977), and Fisher (1981). Bigg (1973) made the most recent assessment of California sea lions in British Columbia, noting about 470 animals off southern Vancouver Island in 1972.

In 1971–84, aerial censuses were undertaken of both species in British Columbia. Records were also obtained on the daily numbers of animals at certain haulouts, and the results of earlier censuses were collated. I recently listed the available data on censuses, sightings, and kills of both species in British Columbia, for the period 1892–1982 (Bigg 1984). In this paper, I analyze these data to determine the important sites that were used by each species, the season of use, and the annual number seen and killed on them. Many previously undocumented sites are reported, and a classification for site use is given. The likely pattern of seasonal movements in British Columbia is described for each species. Evidence is discussed for the concern that fishermen have expressed during the past few years about an increase in the number of both species of sea lion off Vancouver Island. The trends in population size of each species during this century are described, with particular emphasis placed on a reexamination of data on the historical estimates. Consideration is given to the role of the herd reduction programs, and the growth of rookeries at Forrester Island, Alaska, on observed changes in population size of Steller sea lions in British Columbia.

Methods and Data

Bigg (1984) gave the sources, methods of collection, and possible biases of data gathered on the number seen and killed up to 1982. Most of these data were collected by the Fisheries Research Branch and Field Services Branch of the Canadian Department of Fisheries and Oceans. Census data consisted of systematic counts at rookeries and at other aggregations during the year, and opportunistic sightings recorded by other observers. Counts prior to 1971 were made generally by eye from boats, land, or air. Pike and Maxwell (1958) reported that visual counts made from aircraft differed between observers by up to 10%. A large number of previously unpublished sightings were obtained from an examination of annual field reports of the Fisheries Research Branch for the period 1956–66, and the Field Services Branch for 1922–70.

Counts made during 1971–84 were taken mainly from aerial photographs. Aerial censuses were made with a *DeHavilland Beaver* and *Cessna* 172, 180, and 185, flown at an altitude of 150 m and speed of 150 km/h. All sites known or suspected to have sea lions of either species present were surveyed. Photographs were taken with a hand-held 35-mm camera equipped with 135-mm and 200-mm telephoto lenses. The film used was *Kodak Ektachrome* ISO 200 and ISO 400. Other sightings were taken mainly by lighthouse keepers, and biologists, with a few by naturalists.

Only a few sea lions killed during 1913–68 were known to have been California sea lions, and hence essentially all kills can be considered to have consisted of Steller sea lions. The kills consisted of three kinds: the Field Services Branch conducted kills for management purposes to reduce the size of the herd; the Fisheries Research Branch undertook kills for research purposes to collect specimens, and occasionally to reduce numbers; and entrepreneurs killed sea lions for commercial purposes, such as for meat, fat, and hides. The number noted as killed for research and commercial purposes was probably accurate. However, based on conversations with personnel from the Department of Fisheries and Oceans, who participated in the control programs, the number reported as killed for management purposes was probably inflated. Sea lions were shot from land and vessels, and many animals reported as killed may have been only wounded, or assumed to have been shot. The most accurate figures were collected during 1956–68, when 46% of all reported kills were made for research and commercial purposes, compared to only 3% during 1912–55. Although the

accuracy of some figures is questionable, they are presented because they are the only indicators of killing intensity and timing.

Addition animals were killed by other groups, although quantitative data are not available. Indians killed sea lions for food, and fishermen shot sea lions on an opportunistic basis. In both cases, the number killed was probably small compared to that reported for control purposes. Also, according to senior fisheries officers within the Field Services Branch, the Canadian airforce and navy apparently killed a large number of sea lions on rookeries and nonbreeding sites during the Second World War, as part of the war effort to aid fishermen. This kill continued on a much reduced basis up to 1958 (Bigg 1984).

The data on numbers seen and killed are extensive and varied in quality. In this analysis, I have tried to use the most significant and reliable figures, so as to provide a conservative analysis, particularly in the assessment of trends in population size. I use the term pup to refer to a sea lion up to 6 months of age, and nonpup for one older than 6 months.

Results and Discussion

Steller Sea Lions

Site Classification

Steller sea lions in British Columbia congregate at four kinds of sites.

1. Rookeries. These sites are located farthest from land masses, and are the most exposed to oceanic swells (Fig. 1). Essentially all births and breeding takes place there. Some animals are usually present throughout the year (Table 1), with the largest number seen in July. In summer, rookery populations are composed of cows, pups, bulls, and juvenile males and females (Gentry 1968, 1970; Edie 1977; Orr and Poulter 1965). In winter, they have mainly cows with young-of-the-year.

2. Year-round haulouts. These are usually found in locations that are exposed directly to oceanic swells, but unlike rookeries, are located close to land masses. Births rarely occur there, and matings apparently do not take place (Harestad and Fisher 1975). Animals are present year-round, with no marked seasonal variation in numbers seen. The presence of animals during June–July is particularly characteristic. The population composition in summer appears to consist of either young bulls, or a mixture of ages and sexes (Pike and Maxwell 1958; Harestad and Fisher 1975). In winter, bulls, and cows with young-of-the-year are present, along with other animals of unknown age and sex.

3. Winter haulouts. These are found in exposed locations, similar to those of year-round haulouts, and in sheltered inlets and channels. Sites in exposed locations generally are not exposed directly to oceanic swells, but rather are sheltered to some extent by the surrounding topography, such as within a bay, or on the leeward side of an island. The sites tend to be smaller than the other kinds of haulouts. The main period of occupancy is winter, although sea lions can be present from August to May. Occupancy can be continuous or intermittent. Sites where less than about 50 animals hauled out are used least frequently. The absence of animals, or the presence of only a few individuals, during June–July is characteristic. Occasionally, winter sites located in exposed areas appear to be used in June–July by animals normally present on nearby year-round haulouts. Some winter sites in sheltered waters contain only adult and subadult males. Exposed sites generally have bulls and cows with young-of-the-year, plus other individuals of unknown age and sex.

4. Winter rafting sites. Where no suitable haulout site is available, sea lions rest on the water surface in a tightly packed group, or raft. Rafting sites are found mainly close to shore in sheltered inlets and channels, but occur sometimes in exposed localities. The exact

TABLE 1. Percentage of days during each month when Steller sea lions were seen on rookeries, year-round haulouts, and exposed winter haulouts in British Columbia during 1956–82.

Site		Month											
		J	F	M	A	M	J	J	A	S	O	N	D
Rookeries	%	100	100	100	100	100	100	100	100	100	—	—	100
	(*n*)	(6)	(3)	(4)	(10)	(27)	(52)	(20)	(11)	(7)	—	—	(12)
Year-round Haulouts[a]	%	100	100	100	100	95	95	100	85	100	100	100	83
	(*n*)	(7)	(8)	(8)	(14)	(39)	(91)	(49)	(27)	(11)	(2)	(2)	(23)
Winter Haulouts[b]	%	93	95	86	100	88	26	36	82	75	77	100	96
	(*n*)	(15)	(22)	(14)	(10)	(9)	(61)	(14)	(17)	(16)	(4)	(6)	(28)

[a]For sites listed in Table 4.

[b]For sites listed in Table 6 except Miller Group, Ashdown Island, sites with less than 50 animals usually present, and sites off southern Vancouver Island between Carmanah Pt. and Denman Island.

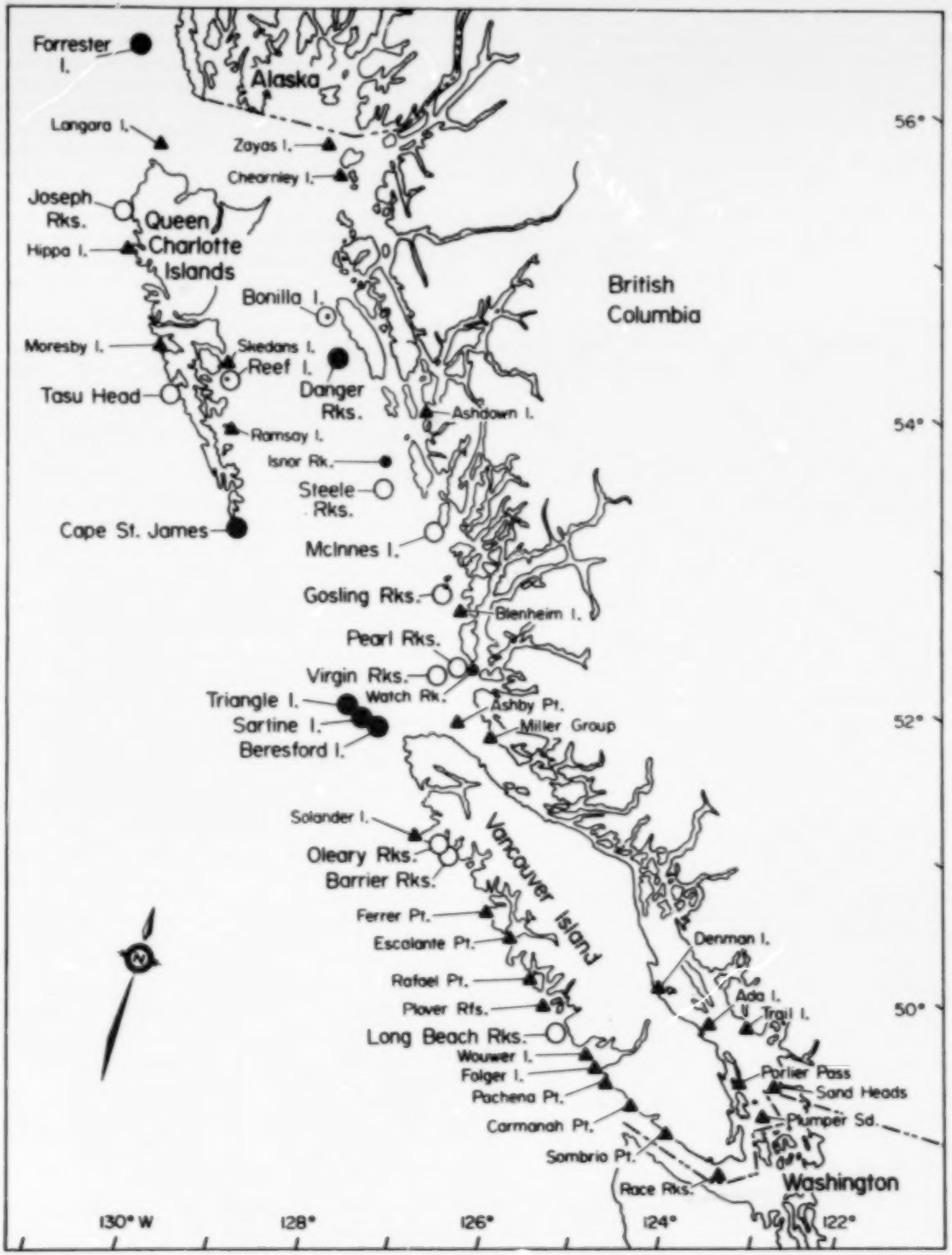

FIG. 1. Geographical location of current rookeries (●), year-round haulouts (○), and winter sites (▲) of Steller sea lions in British Columbia. Only winter sites with ≥ 50 individuals usually present are noted.

location of rafts may change by several miles during the year, perhaps in response to changes in the location of the food supply. Rafts are most commonly seen in winter, but may be present from fall to spring. The age and sex composition of animals at these sites is not known.

Examples will be given later of sites which, over the years, changed from one kind to another.

Numbers on Rookeries

The precise pattern of seasonal variation in numbers on rookeries must be understood before annual trends in numbers can be determined. A review of existing knowledge about seasonal variations is worth incorporating here because much of this information is found only in reports that are not easily accessible, and has not been summarized. The pattern of seasonal variation appears to be the same throughout the range of the species. The number of animals on rookeries is typically largest during summer and smallest during winter (Orr and Poulter 1965; Gentry 1968, 1970; Calkins and Pitcher 1982). Pike and Maxwell (1958) felt that the annual peak in number in British Columbia occurred during early July, and Withrow (1982, quoted in Loughlin et al. 1984) suggested it occurred during mid-June to mid-July in Alaska. Evermann and Hanna (1925), and Bartholomew and Boolootian (1960) observed that the seasonal timing of births was the same throughout the range. In British Columbia, as elsewhere, births take place from late May to mid July (Pike and Maxwell 1958; Edie 1977). Figure 2 shows the remarkable similarity in the sequence of pupping on seven rookeries located between California and Alaska. The number of pups born by date was taken from studies by Mathisen et al. (1962), Gentry (1968), Sandegren (1970), Edie (1977) and Calkins and Pitcher (1982). Unfortunately, the sequence of pupping cannot be easily quantified as the data do not fit either logistic or cumulative normal distributions. Asymmetry of the data may be caused by the termination of some studies before pupping was completed, or by natural mortality of pups during the pupping season. On average, 99% of births were completed by 5 July.

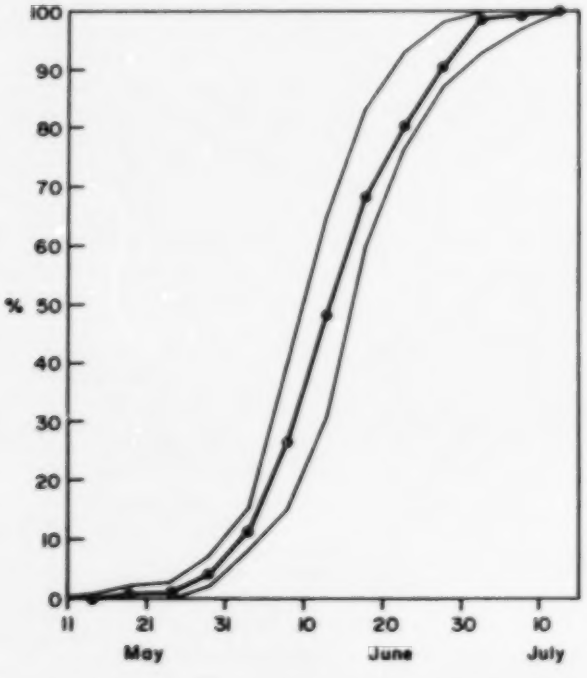

FIG. 2. The mean and range for the cumulative percentage of Steller sea lion pups born, at 5-day intervals, on seven rookeries between California and Alaska.

The total number of animals of all ages seen on rookeries begins to increase at the start of the birth season and to decline after the mating season. The number of bulls reaches a peak in early to mid June, while the peak for juvenile males is late June, and that for cows and younger females, mid to late June (Gentry 1968; Edie 1977). The number of cows using the rookery must continue to increase until early July, as indicated by the pupping sequence. Presumably, late in the season more cows leave to forage than arrive to pup. Cows give birth within a few days of arrival on the rookery, and mate about 1–2 weeks later (Gentry 1970; Sandegren 1970; Edie 1977). The main time for the departure from the rookery of all individuals, except cows with pups, begins in late July–mid August (Pike and Maxwell 1958; Gentry 1968, 1970; Orr and Poulter 1965; Le Boeuf and Bonnell 1980). Cows with nursing pups cannot leave until the pups learn to swim, in August-September (Orr and Poulter 1967; Sandegren 1970). Pups continue to nurse until at least September, and some continue for one year (Gentry 1968, 1970). After July, the number of animals on the rookery declines to a low level by winter, and does not increase again until just before the next birth season (Orr and Poulter 1965; Gentry 1968, 1970; Le Boeuf and Bonnell 1980).

Year-round counts were not made at any rookery in British Columbia but the pattern of variation just described was confirmed indirectly. Over the years, counts were made at rookeries during most months, and these data showed changes in the number present by month relative to the number seen in July. Figure 3 indicates that numbers usually decreased to the lowest levels in January–April, then increased in May. Typically, the number present in December was about 25% of that seen in July (Table 7). This review suggests that the largest numbers seen on rookeries in British Columbia, and elsewhere, was usually during July, after pupping but before dispersion.

Not all censuses undertaken during summer in British Columbia were made in July. Some were made in June and August, and hence were not comparable to those in July. One bias that can be corrected is the number of pups yet to be born for those censuses made in June. I used

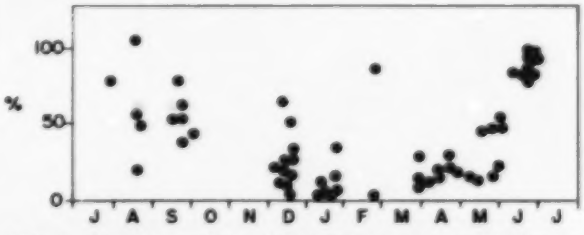

FIG. 3. Monthly variation in the total number of Steller sea lions on rookeries in British Columbia during 1956–82, as indicated by the percentage of the total number seen on rookeries in the preceeding or subsequent July.

Figure 2 to extrapolate the probable number that would have been born by 5 July for censuses taken after 20 June, and added the extra pups to the total numbers seen. The potential for error in extrapolation increases substantially for censuses undertaken prior to 20 June. No correction was made for the number of sea lions that may have been at sea during censuses, or for censuses taken in August. The counts made in August would, in general, be lower than if taken in July because movements off rookeries can begin in late July.

Most individuals seen on rookeries in British Columbia were probably born there. Homing to the birth site is suggested from tagging studies on pups of this species in Alaska (Calkins and Pitcher 1982). Also, behavioural observations on the rookery at Cape St. James, British Columbia, indicate that adult females tend to return to the same rookery each year (Edie 1977). Homing to the site of birth is a well known phenomenon in the northern fur seal, *Callorhinus ursinus*, the only other species of otariid examined for this behaviour (Kenyon and Wilke 1953). Thus, each rookery in British Columbia may be a separate breeding stock.

The counts on rookeries provide two indices of stock size. The first is the total number of pups and nonpups seen. It gives a minimum estimate of stock size. Additional nonpups may be absent from rookeries due to foraging at sea, and to dispersal to year-round haulouts in British Columbia, and elsewhere along the coast of the eastern North Pacific Ocean. The second index is the number of pups born and is related to the first. This is the best index of stock size because the total size of the population can be estimated using life table statistics. Unfortunately, the number of pups born was not always separated from the total number seen in early studies. Estimates of the number of pups born can be biased by annual differences in natural mortality during the birth season. Storms sometimes kill large numbers (Pike and Maxwell 1958; Orr and Poulter 1967; Edie 1977).

In British Columbia, eight rookeries are known to have existed during this century (Table 2). The rookeries of Triangle Island, Sartine Island, and Beresford Island are sometimes collectively referred to as the Scott Islands, and the Virgin Rocks, Pearl Rocks, and Watch Rock as the Sea Otter Group. During 1913–82, nine major censuses were undertaken in summer, and two in winter. Rookeries other than those mentioned by Pike and Maxwell (1958) were not found in the current study. The kills for control purposes took place mainly on rookeries (Table 3).

Before beginning an interpretation of data on the number of sea lions seen on rookeries, consideration must be given to the effect that the killing operations may have had on the behaviour of sea lions. Killing operations that took place during censuses could have driven some nonpups away from rookeries, and perhaps to other sites. An examination of the timing of kills and censuses indicates that some counts were not affected by killing operations. For example, no kills occurred on rookeries during censuses in 1916 and 1971–82. Killing was unlikely to have been a factor in 1956 when only a few individuals were killed on the Scott Islands before the census. Killing may have altered the distribution of sea lions before censuses were made on certain rookeries during 1913, 1938, and 1961. In these instances, individuals could have been driven from the rookery, and then either remained at sea, or gone to other haulouts. In the first case, counts would be too low on the site of disturbance, while in the second, the count would be inflated on the site to which animals were driven. However, Pike and Maxwell (1958) felt that animals frightened off rookeries during kills tended to remain swimming nearby in rafts, and hence would still be counted at the site of disturbance. Certainly the annual kills on the Sea Otter Group during 1922-39 (Table 2) did not discourage sea lions from returning each year. Peterson (1968) noted that, in one instance, tagging operations made in late July on Año Nuevo Island, California, drove animals away for only 2 days. In another instance, most animals did not return even after a month. Thus, the response to disturbance could vary.

TABLE 2. Total number and number of pups (in parentheses) of Steller sea lions seen on rookeries in British Columbia, and on Forrester Island, Alaska, during major summer and winter censuses in 1913–82. Censuses in June that are increased by the additional number expected to be born by early July are indicated by an asterisk.

		British Columbia								Alaska
Year	Date	Triangle I.	Sartine I.	Beresford I.	Virgin Rocks	Pearl Rocks	Watch Rock	N. Danger Rocks	Cape St. James	Total	Forrester I.
Summer											
1913	12/6–28/8—[a]	350(50)	0	3200(700)	2300(1000)	1410(385)*	103(15)*	1000	2500*(+)	10863	50–100, pre 1929[g]
1916	22/6–11/7—[b]	(0)	0	6000	2688(1188)*	259(59)*	3(0)	1000	1000	10950	
1938	16–19/8 —[b]	1200	2	2000	4000(4)	12(2)	(0)	2000	2800	12014	350, Aug. 1945
1956	3/7–1/8 —[b]	1750(400)	850(300)	1700(750)	(0)	(0)	(0)	1100(300)	4000(1500)	9400(3250)	2500, spring 1957[g]
1961	20–23/6* —[b]	1085(385)	785(385)	935(385)	(26)	(0)	(0)	308(128)	1441(644)	4554(1950)	2396(1096)
1971	28–30/6* —[c]	751(201)	809(181)	680(191)	(0)	(0)	(0)	241(93)	991(360)	3472(1026)	
1973	29/6–3/7*—[c]	580(205)	914(298)	689(204)	(0)	(0)	(0)	440(93)	821(272)	3444(1072)	6187(2400)
1977	26–30/6* —[c]	720(150)	1209(330)	820(168)	(0)	(0)	(0)	300(70)	1111(329)	4160(1047)	5308(2187), 1981[g]
1982	26/6–1/7*—[c]	581(205)	1260(454)	732(190)	(0)	(0)	(0)	268(80)	1130(432)	3971(1361)	5528(2227)
Winter											
1971	9–12/12 —[c]	482	88	87				48	258	963	
1976	14–17/12 —[c]	369	36	138				104	310	957	438

Sources: [a]Newcombe and Newcombe (1914); [b]Newcombe et al. (1918); [c]Current study; [d]Rowley (1929); [e]Imler and Sarber (1947); [f]Mathisen and Lopp (1963); [g] Loughlin et al. (1984); [h] Pike and Maxwell (1958) and Bigg (1984).

TABLE 3. Total number of Steller sea lions reported killed in British Columbia on rookeries and nonrookeries during 1912–68. Number of pups included in parentheses.

Year	Rookery							Non-rookeries	Total
	Triangle I.	Sartine I.	Beresford I.	Virgin Rocks	Pearl Rocks	Cape St. James	N. Danger Rocks		
1912								2 000	2 000
1913			500(+)	22 (15)	105 (81)				627 (96)
1914				750					750[a]
1915			2 290+ (800+)	1 556+				242	4 088+(800+)[a,b]
1922					220 (0)				220 (0)
1923				1 760 (649)	125 (5)				1 885 (654)
1924				2 236 (903)	470 (312)				2 706 (1215)
1925				2 587 (1067)	240 (102)				2 827 (1169)
1926				1 442 (565)	514 (146)				1 956 (711)
1927				1 493 (635)	170 (40)				1 663 (675)
1928				1 007 (375)	32 (2)			103	1 142 (377)
1929				1 217 (522)	126 (7)			16	1 359 (529)
1930				1 008 (568)	60 (24)				1 068 (592)
1931				1 286 (523)	71 (12)				1 357 (535)
1932				1 128					1 128
1933				813 (212)	110 (1)				923 (213)
1934				614 (125)	172 (0)				786 (125)
1935				602 (110)	21 (0)				623 (110)
1936			3 529 (1043)	167 (73)	111 (2)			60	3 867 (1118)
1937			2 061 (428)	157 (62)	24 (0)			343	2 585 (490)
1938		867 (513)	1 207 (535)	25 (4)	29 (2)		122	1 002	3 252 (1054)
1939			821 (815)	139 (34)	13 (9)			272	1 245 (449)
1940							75 (0)	59	134 (0)
1941								111	111
1942								208	208
1943								45	45
1944								97	97
1945								293	293
1946								304	304
1947						12		263	275
1948								113	113
1949	26	26	35			50		227	364
1950		1 878 (220)						232	2 110 (220)
1951								231	231
1952						50 (0)		202	252 (0)
1953	95 (0)							216	311 (0)
1954		33 (0)				35 (0)	6	106	180 (6)
1955								176	176
1956		165 (117)						134	299 (117)
1957								521	521
1958	25	6	6				377 (158)	689	1 103 (158)
1959	1 107 (471)	64 (0)	1 077 (401)			352 (145)	111 (33)	677	3 388 (1050)
1960	111 (0)	14 (0)	59 (0)			1 438 (0)	121 (62)	310	2 053 (62)
1961	35 (0)	38 (5)	35 (0)			543 (0)		165	816 (5)
1962	23 (0)		49 (0)			480 (0)	193 (80)	638	1 383 (80)
1963	117 (0)	24	117 (0)			150 (0)	66 (1)	563	1 037 (1)
1964	139 (0)	157 (0)	324 (50)			254 (23)		103	977 (73)
1965		309 (246)				169 (110)			478 (356)
1966	43 (0)	25 (0)	64 (0)			44 (0)		51	227 (0)
1967							15	55	70
1968								15	15

[a]Up to 75% may have been pups.
[b]1 063+ were killed on the Virgin Rocks, and hundreds were killed on Pearl Rocks.

The possibility cannot be ignored that persistent harassment at a rookery during the summer temporarily drove some animals to nearby rookeries, particularly between rookeries within the Scott Islands, or within the Sea Otter Group. Evidence will be presented later that suggests sometimes animals were driven between rookeries of the Scott Islands. But no evidence exists to indicate that animals were driven between more distant rookeries, such as between the Scott Islands, Sea Otter Group, Cape St. James, and North Danger Rocks, or between rookeries and nonbreeding sites. Only on rare occasions during the 1950's and 1960's were a few pregnant females apparently driven from kills on rookeries to pup on the abandoned rookeries of the Sea Otter Group. No pupping was observed on other nonbreeding sites during the control programs. Presumably a homing tendency was a powerful force to keep animals returning to their rookery of birth. This being the case, the control kills during 1913, 1938, and 1961 may have caused only local changes in distribution. In 1913, kills occurred before the census only on the Scott Islands. In 1938, this happened only on the Scott Islands

and Sea Otter Group, and in 1961, only on Cape St. James (Bigg 1984). Counts on the other rookeries during those years were probably not influenced by killing operations elsewhere.

The following account examines the history of numbers seen and killed on each rookery. Emphasis is placed on the evidence that I use to establish which censuses were the least biased by killing operations or by date of census.

Triangle Island

Triangle Island was apparently a large rookery prior to 1913, but beginning in 1909, sea lions were shot or driven away during the construction and servicing of a lighthouse on the island (Newcombe and Newcombe 1914; Pike and Maxwell 1958). Pupping is thought to have ceased between 1913 and 1916. The rookery probably reestablished itself within a few years, because the lighthouse was abandoned by 1920, and many animals were present by 1938. No control programs were directed there prior to 1949. A kill during 1958–66 resulted in reduced numbers present by 1971–82.

Sartine Island

This was not a rookery early in the century. No animals were seen there in the censuses of 1913 and 1916. Newcombe and Newcombe (1914) interviewed local Indians familiar with the area who indicated that Sartine Island was not a rookery, whereas Triangle Island and Beresford Island were. Still, Pike and Maxwell (1958) suggested that Sartine Island was a rookery, but was missed during the censuses. It was a rookery on 13 June 1938 when 513 pups were reportedly killed (Bigg 1984), although only two animals were present by August 193[illegible]. But, pup counts on Sartine Island during control programs must be interpreted with caution. Kills on the nearby rookeries of Beresford Island and Triangle Island, to the east and west, sometimes apparently caused animals to be driven to it. In the most extreme example of this bias, G. Pike recorded 800 pups on Sartine Island by 14 June 1960. Had this number represented the natural arrival rate of cows, then 1 500 pups would have been born by early July. This was a number far in excess of that found on the rookery in other years. Pike, in his 1960 field notes, suggested that the unusually large numbers of pups probably resulted from killing operations on Beresford Island and Triangle Island, which drove pregnant females to Sartine Island. Thus, extrapolating for the number of pups that were likely to have been born by the end of the birth season would, in this case, result in an unrealistically large number. A large kill occurred on Beresford Island earlier in June 1938, and so some of the 513 pups killed on Sartine Island may have been born to cows driven from Beresford Island. Perhaps, the rookery on Sartine Island formed as a result of animals being driven from the large kills on Beresford Island during 1913–38.

During 1959–61, Sartine Island was designated a research area with management and commercial kills forbidden. Nonetheless, small kills for research, management, and commercial purposes still continued during 1956–67. The production of pups changed little between 1956 and 1971–82. With only small kills on Sartine Island, few animals were probably driven from Sartine Island to Beresford Island and Triangle Island. No other obvious cases exist where pregnant cows were driven between rookeries in British Columbia.

Beresford Island

Of the counts made on Beresford Island in 1913 and 1916, that in 1916 was probably the most representative of the maximum numbers present in July. The count in 1913 was made late in the season (18 August), and after a commercial kill of 500 animals. The count in 1916 was made close to the optimum time (27 June), and was not preceded by a kill. Pike and Maxwell (1958) felt that the 1916 count may have been exaggerated, yet Newcombe et al. (1918) clearly stated that "The lowest estimate made as to the number (on Beresford Island) was 6000." A somewhat higher number may have existed in 1913. During 1913–15, a reported 2 800 animals were killed, although up to 75% of these may have been pups (Newcombe et al. 1918). The count in 1938 was made late in the season, and followed kills reported to total 6 800 seal lions (including 2 000 pups) in 1936–38. In 1950, 1 900 sea lions were noted as killed on the Scott Islands. As most kills during these early days where made on Beresford Island, such may have been the case in 1950. By 1956, the population had declined. Large kills followed during 1956–67, which resulted in even smaller numbers by 1971–82. Over the years, killing eliminated pupping at one site. Up to 1966, pups were born on the main island and a large rock to the north (Maggot Island), but during 1971–82, they were born only on the northern rock.

Virgin Rocks

Of the counts made on the Virgin Rocks in 1913 and 1916, that in 1916 probably best indicated the magnitude of numbers present in July. The count in 1913 was made late in the season (28 August), while in 1916 it was made on 25 June. The number present in 1913 was probably somewhat higher than in 1916 in that more than 2 000 animals were reported killed here during 1914–15, although many were reported to be pups. An intensive annual kill was undertaken during 1923–39, and pupping progressively decreased to low levels by 1939 (Table 3). An unusually large number of nonpups was counted in August 1938. These animals must have originated elsewhere, because the population on the rookery was almost eliminated by this time. Field reports of fishery officers in 1938 suggested that the sea lions came from the Scott Islands. The large number of animals seen on the Virgin Rocks could have been part of the postbreeding season dispersal from the Scott Islands, or could have been driven from kills there. Pupping has occurred rarely since, and the Virgin Rocks are used now as a year-round haul-out.

Pearl Rocks

The counts in 1913 and 1916 were made fairly close to the optimum time, on 22 June and 25 June, respectively. But, the numbers seen decreased sharply between 1913 and 1916, no doubt due to control kills. The magnitude of the kills was not known, but early records indicate that hundreds of animals were killed on the Sea Otter Group without the exact rookery being noted. The census in 1913 appears to be the best indicator of the maximum numbers present. An intensive annual kill occurred during 1922–39

and gradually eliminated pupping by the 1930's (Table 3). Pupping has not occurred since, and the site is now used as a year-round haulout.

Watch Rock

This site was noted as a rookery only on 22 June 1913. It was probably eliminated during the kills on the Sea Otter Group of 1913–15. No pups have been found here since, and the site is now abandoned.

Cape St. James

Of the counts made in 1913 and 1916, that in 1913 was probably most indicative of the numbers present in July. A total number of 2 000 was noted on 12 June 1913 (Newcombe and Newcombe 1914). This count was made early in the season, and so underestimated the number of pups and nonpups that would have been present in early July. Newcombe et al. (1918) suggested adding 500 to this number to account for pups not yet born. The additional number was probably reasonable, although more appropriate for the total increase in number of pups and nonpups present by early July, rather than just for the number of pups. While an extrapolation for the total number present in July, based on counts made so early in the pupping season is prone to error, the importance of an estimate of numbers present in July 1913 makes some speculation necessary. Using daily counts made by Gentry (1968, 1970) on the rookery at Año Nuevo Island, California, total numbers probably increased by about 25% between 12 June and 5 July, or about 500. Only 1 000 sea lions in all were seen on 13 July 1916. No indication was given as to whether these consisted mainly of pups or nonpups. The reason for the decline between 1913 and 1916 is not clear. No control kills were directed there during this time. Newcombe et al. (1918) felt the decline was due to natural variability in the number of animals hauled out each year. Yet, large variations were not observed during 1971-82 (Table 2). The decline was probably due to harassment prior to the census in 1916, from personnel and servicing vessels for a lighthouse that was erected near the rookery after the census in 1913, and completed by early 1914.

A count late in the season during 1938 noted 2 800 present, and an increase in numbers occurred by 1956. No kills were reported on the rookery up to this time. Large kills during 1959–1967 sharply reduced numbers between 1956 and 1971–82. With a commercial kill of about 500 adults preceding the count in 1961 (Bigg 1984), some nonpups may have been driven from the rookery, to result in an underestimate for the number of animals reported there in 1961.

North Danger Rocks

This small rookery was not censused in 1913 or 1916. But, Newcombe and Newcombe (1914) interviewed Indians who indicated that it was a rookery containing perhaps 1 000 sea lions. Essentially no kills occurred there between 1913 and 1957. In 1958–67 a relatively large kill was conducted, resulting in a decline in numbers between 1956 and 1971–82.

Forrester Island

The rookeries off northern Forrester Island, Alaska (Fig. 1), are important to consider in this study because of their proximity, and their possible effect on the growth of stocks in British Columbia. These rookeries have increased remarkably in size, and may have formed in the 1910's or 1920's. Rowley (1929) mentioned, without giving a date, that a rookery existed there with only 50–100 individuals. Since then the population has steadily increased, and stabilized during 1973–82 (Table 2). Between 1961 and 1973, the production of pups increased at an average rate of 6.8% annually. The only kill reported was 190 sea lions in 1960 (Bigg 1984). While control programs resulted in decreased numbers of animals on most rookeries in British Columbia, the lack of kills at Forrester Island allowed these rookeries to increase in size.

Effect of Kills on Pup Production

A crude estimate of the relationship between the number of sea lions reported to have been killed in British Columbia, and the decline in the population during 1956–68 can be determined from the data given in Table 2 and Table 3. In all, 8 446 animals were killed on rookeries, and 3 921 on nonbreeding sites. About 15% of the kill consisted of pups. This proportion would be higher if one assumed that the killing of nursing cows on rookeries also resulted in the death of pups through starvation. Still, the kill was directed mainly at nonpups, and the kill of pups was probably not important to the overall reduction in the size of the breeding stock. A high natural mortality is experienced during the first year of life (Calkins and Pitcher 1982). The decline in the total population between 1956 and 1968 is not known with certainty, although the number of pups born between 1956 and 1971 decreased by 2 224. With little change in the number of pups born during 1971–77, a reasonable assumption is that the numbers of pups present in 1968 was of a similar magnitude. For all of the rookeries in British Columbia combined, an average of 2.9 nonpups were killed for each pup reduced. For the Scott Islands, the ratio was 3.2:1, for Cape St. James it was 2.8:1, and for North Danger Rocks it was 2.7:1.

The kill at nonbreeding sites no doubt also contributed to the decline in the production of pups on rookeries in British Columbia. Essentially all of these kills were nonpups. Combining the kill at all nonbreeding sites, an average of 1.8 nonpups were killed per pup reduced on rookeries. Unfortunately, the rookery of origin for those killed at nonbreeding sites was not known. Data presented later suggest most animals on winter haulouts originate from rookeries in British Columbia, with some sea lions originating from rookeries in California, Oregon, and possibly Alaska. At present, the kill at nonbreeding sites cannot be apportioned to any particular rookeries. Hence,

TABLE 4. The year-round haulouts in British Columbia, numbers of Steller sea lions seen on them during 1956–82, and history of site use.

Haulout	June–August			September–May			History	
	$\bar{x}$	Max	n	$\bar{x}$	Max	n	First noted	Changes in use
Long Beach Rocks	134	394	27	132	350	22	1913	
Barrier Rocks	115	250	7	155	398	4	1955	
O'Leary Rocks	155	331	15	162	305	14	1955	
Solander Island	156	350	7	85	200	8	1913	Winter site since mid-1960s
Virgin Rocks	256	800	16	177	370	11	1913	Rookery up to 1930s
Pearl Rocks	100	276	16	104	300	11	1913	Rookery up to 1930s
Gosling Rocks	59	179	8	82	223	9	1956	
McInnes Island*	70	196	12	74	150	8	1938	
Steele Rocks	88	150	3	157	182	2	1971	Newly formed
Isnor Rock	142	250	5	78	160	3	1913	Abandoned since mid-1960s
Bonilla Island	144	350	10	93	144	4	1913	
Reef Island	148	300	14	149	600	9	1956	
South Tasu	105	278	5	76	200	5	1940's	
Joseph Rocks	278	408	14	390	500	2	1930	
Langara Island	136	450	8	187	350	2	1937	Winter site since mid-1960s

*Excludes data in Fig. 4.

with some animals probably originating from rookeries outside of British Columbia, the ratio would be less than 1.8:1 for stocks originating in British Columbia.

Assuming that the age and sex composition of animals present in British Columbia during the year was not biased for a self-reproducing population, the kill of nonpups may well have been close to random. Killing took place wherever animals were seen during the year, at rookeries, year-round haulouts, winter haulouts, and rafting areas. The kill for commercial purposes was directed mainly at adult males and cows on rookeries during summer, while the kill for management purposes tended to be random, and was directed at both rookeries and nonbreeding sites in summer and winter. The kill for research purposes was relatively small, and tended not to be selective. It took place mainly in summer at rookeries and nonbreeding sites. Also, the life tables for this species derived by Calkins and Pitcher (1982), indicate that 3.5 nonpups exist per pup in a self sustaining population. The ratio of the number of nonpups killed per pup reduced in British Columbia during 1956–68 may have been close to this theoretical ratio. Although the combined ratios from kills on rookeries and nonrookeries in British Columbia was higher, 4.7:1, it was also biased. The number of nonpups reported killed for management purposes was inflated, and not all nonpups killed on nonbreeding sites were likely to have been born on rookeries in British Columbia.

NUMBERS ON YEAR-ROUND HAULOUTS

All year-round sites used by Steller sea lions in British Columbia since 1956 were probably located during the extensive coastal surveys by vessels and aircraft for sea lions. Table 4 shows that of the 15 sites known during 1956–82, only 12 were used since the mid 1960's. Pike and Maxwell (1958) noted all of the sites listed, except for Long Beach Rocks, Barrier Rocks, O'Leary Rocks, and Steele Rocks. Solander Island and Langara Island have not been used regularly in summer since the mid 1960's, and may now be used only as winter haulouts. Steele Rock appears to have replaced nearby Isnor Rock as a year-round haulout.

The year-round haulouts were used by sea lions over many years, in some cases extending back to 1913. Information for other sites extends back only to the 1930's–1950's due to the absence of early records about any sites other than rookeries. All year-round sites were subjected to repeated kills over the years. Yet, sea lions returned, presumably because each site had some long-term attraction, such as for food, security, or tradition.

The number seen on each year-round haulout during 1956–82 was typically 50–250 animals throughout the year, depending on the site (Table 4). Table 5 supports the view that the numbers present do not vary much between summer and winter. Similarly, Fig. 4 shows the maximum number seen each month on McInnes Island during 1963–64 did not vary markedly through the year. Unfortunately, the records for daily counts at this site were lost. Harestad

TABLE 5. Total number seen and estimated at year-round haulouts for major censuses made during summer and winter 1957–82. Number of sites missed in parentheses.

Year	Date	Seen	Missed*	Total
Summer				
1957	27 6–17 8	2 097	0	2 097
1961	20–23 6	1 350	354 (3)	1 704
1964	8–11 6	1 249	308 (3)	1 557
1971	28–30 6	2 170	203 (2)	2 373
1977	27 6–2 7	2 003	0	2 003
1982	28–30 6	1 781	0	1 781
Winter				
1971	7–12 12	1 021	545 (2)	1 566
1976	13–21 12	1 489	0	1 489

*The average number given in Table 4 is used for sites missed.

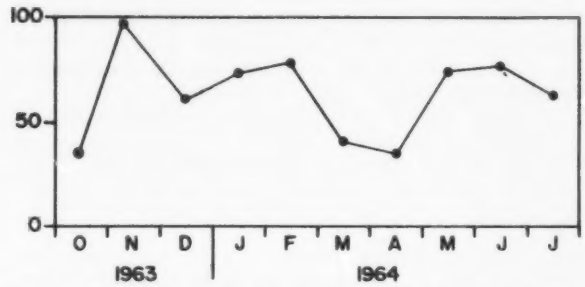

FIG. 4. Maximum number of Steller sea lions seen each month on McInnes Island by lighthouse keepers during 1963–64.

(1977) recorded the number of sea lions seen on McInnes Island during 1972–73, but noted a peak in mean numbers of 100 animals during June, and a decrease to a mean of less than 25 for most other months.

Pike and Maxwell (1958) felt that considerable annual and seasonal variation occurred in number of animals on nonbreeding sites. An inspection of the data used to derive Table 4 confirms that daily numbers were quite variable. However, the variability was, at least in part, due to temporary departures of animals from the sites, caused perhaps by storms or harassment. Our aerial surveys indicated that a search in the vicinity of sites where no animals, or only a few animals, were hauled out often found the sea lions swimming in rafts nearby. Thus, animals tended to remain in the area, although were not always hauled out at the year-round site. In this regard, the mean number hauled out per month is not a particularly good indicator of the number of sea lions using the site. Frequent temporary departures can severely bias the mean number as an indicator of site importance. The maximum number seen per month is a useful statistic. Figure 5 illustrates this point for an exposed winter haulout.

The total number seen at all year-round sites in summer remained relatively stable between 1957 and 1982, averaging about 1 900 animals (Table 5). That the number of sea lions did not decrease during this time, as found on rookeries, is surprising. The reason may be that the numbers seen on year-round haulouts are not a simple proportion of the numbers on rookeries. An example in which little correlation existed between an increase in numbers on a rookery, and the increase in numbers on a nearby year-round haulout, was Forrester Island and Joseph Rocks. Joseph Rocks is a large year-round haulout

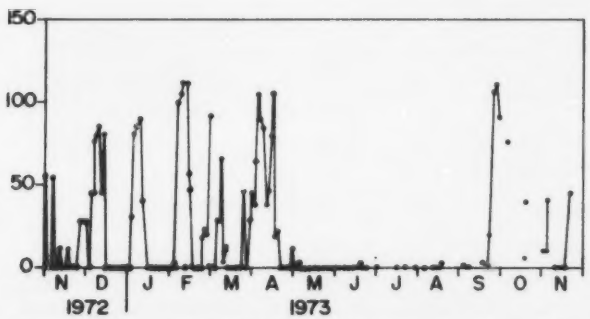

FIG. 5 Daily number of Steller sea lions seen at Pachena Point by lighthouse keepers during 1972–73.

that can physically accomodate many more individuals than it does currently. A 75-fold increase in the number of animals took place on the rookeries of Forrester Island between the 1930's and 1973–82 (Table 2). Yet, only a two-fold increase was seen on Joseph Rocks during the same period (Bigg 1984). Perhaps local food supply limited the number of sea lions that could be supported at a year-round haulout. Emigration could have taken place. Another possibility was that the numbers seen during the 1950's were biased by harassment prior to censuses. Also, the number of animals on year-round haulouts could have been reduced for sea lions born on rookeries in British Columbia, but their reduction was masked by an influx of animals from Forrester Island.

NUMBERS ON WINTER HAULOUTS AND RAFTING SITES

A total of 24 sites was found in British Columbia on which more than 50 Steller sea lions usually hauled out in winter (Table 6). These sites were generally deserted in summer. At least 25 additional winter sites existed at which smaller numbers of sea lions were seen hauled out or rafting (Bigg 1984). These latter sites were found mainly in exposed areas. Little information is available on the historical use of most winter sites, although some were used back to 1913. Most of the effort to census animals at winter sites during 1971–82 was directed at those in exposed coastal areas. The censuses of winter sites during summer probably recorded essentially all animals hauled out or rafting in British Columbia, because the species was not commonly found in sheltered areas at that time. However, censuses of winter sites during winter probably missed small groups of animals located in sheltered inlets and channels. The species appears to disperse widely in exposed and sheltered areas during winter. Censuses during winter in sheltered areas were made only at sites known or suspected to have sea lions present, and hence much of the sheltered coastline was not examined. Still, regional coverage by others was extensive (Bigg 1984) and so few important sites were probably missed.

The first arrivals to winter haulouts in exposed locations were seen during August (Table 1). These animals could have come from rookeries or year-round haulouts. Sites in sheltered areas were probably not occupied until later. This was the case for sites off southern Vancouver Island where arrival times were progressively later eastward, and more distant from summer sites. Daily counts at three sites illustrate the pattern. At Pachena Point, the species arrived in large numbers during September, and was seen frequently through until April (Fig. 5). Animals were rarely seen during May–August. The numbers hauled out during winter were quite variable, apparently because storms caused ocean swells to swamp the haulout, and to drive sea lions into the ocean. At Race Rocks, during 1971, only a few animals began to arrive by September (Fig. 6). Numbers reached a peak in January–March. Too few counts were made in December to be sure of the numbers present in that month. Departures were completed by late May. Records of the numbers seen each day were kept during other years between 1965 and 1979. While these records were not as complete as those for 1971, they nonetheless showed the

TABLE 6. The winter haulouts in British Columbia, numbers of Steller sea lions seen on them during summer and winter 1971–82, and history of site use. Only sites where ≥50 animals were seen regularly are listed individually. Numbers in parentheses were assumed from the subsequent or preceding count.

	Winter		Summer		History	
	1971	1976	1977	1982	First	
Haulout	7–12/12	13–21/12	27/6–2/7	28–30/6	noted	Changes in use
Race Rocks	35	113	0	(0)	1965	Newly formed
Ada Island	0	131	0	(0)	1973	Newly formed
Trail Island	0	91	0	(0)	1973	Newly formed
Miller Group	210	307	0	0	1971	
Ashby Pt.	(31)	31	4	1	1915	
Sombrio Pt.	16	1	0	0	1970	
Carmanah Pt.	0	124	181	170	1938	
Pachena Pt.	24	1	0	0	1970	
Folger Island	284	23	0	0	1955	
Wouwer Island	116	61	0	0	1958	
Plover Reefs	215	185	1	0	1969	
Raphael Pt.	0	36	0	0	1938	
Escalante Pt.	(85)	85	0	0	1955	
Ferrer Pt.	124	217	1	0	1954	
Solander Island	71	34	1	0		See Table 4
Blenheim Island	(65)	65	0	0	1913	
Ashdown Island	(119)	119	0	(0)	1960	
Chearnley Island	(546)	546	0	0	1913	
Zayas Island	(223)	223	0	0	1913	
Ramsay Island	223	396	0	0	1971	
Skedans Island	414	491	0	45	1956	
Moresby Island	57	96	0	0	1957	
Hippa Island	298	292	0	0	1959	
Langara Island	227	121	0	3		See Table 4
Sites with <50 animals	230	222	2	4		
Total	3613	4011	189	223		

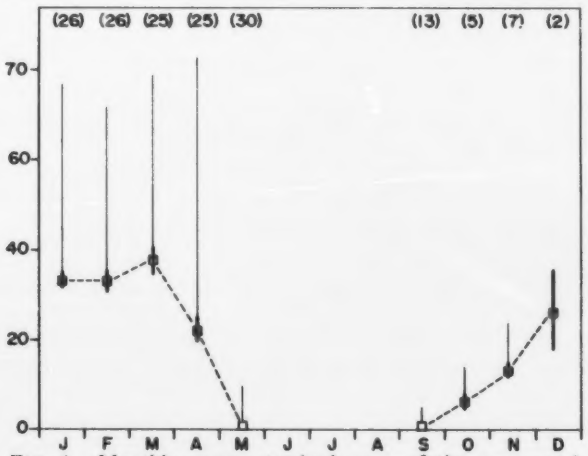

FIG. 6. Monthly mean, standard error of the mean, and maximum number of Steller sea lions seen at Race Rocks by T. Anderson during 1971. Number of days observed in parentheses.

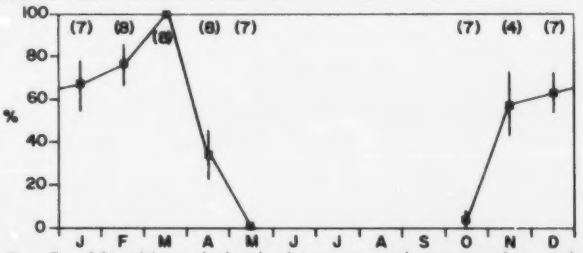

FIG. 7. Monthly variation in the mean maximum number, and standard error of the mean, of Steller sea lions seen at Ada Island by I. MacAskie during 1974–82, expressed as a percentage of the maximum number seen in March of each winter season. Number of years of observation shown in parentheses.

same pattern of arrival and departure (Bigg 1984). At the most inland site, Ada Island, only small numbers arrived by October, most arrived by November, and the largest number occurred generally in March (Fig. 7). All sea lions left by late May. Because of an annual increase in numbers, the seasonal variations in numbers seen at this site were calculated using the percentage of the maximum number seen each month relative to the maximum number seen in March of each winter season. The maximum number noted for each month was used for those months when at least 5 days of observations were made. Ada Island was also occupied by a few California sea lions. In 11 censuses made during 1975–82, Steller sea lions comprised an average of 88% (range 79–97%) of the total numbers seen.

A unique local movement schedule for up to at least 60 individuals was recorded during 1978–82, at Sand Heads, near the mouth of the Fraser River. Fishery officers and lighthouse keepers reported that Steller sea lions arrived in mid March, reached a peak in numbers in late April–early May, and left by late May. The species visited the site apparently to feed mainly on eulachon (*Thaleichthys pacificus*) that spawn in the river at this time. Fishery officers also noted that the species entered

numerous long inlets throughout the mainland coast of British Columbia during February–April to feed on spawning Pacific herring (*Clupea harengus pallasi*), and eulachon (Bigg 1984). Departure from winter sites throughout British Columbia appears to be essentially completed by late May.

Movements

Steller sea lions in Alaska congregate on rookeries during the breeding season, and are thought to migrate locally in winter (Alaska Department of Fish and Game 1973; Calkins and Pitcher 1982). The direction and distance travelled are unknown, although tagging and branding studies undertaken in Alaska and British Columbia indicate that dispersion distances can be large. In April–June, juveniles were seen at haulouts up to 1 500 km from their birth sites (Fisher 1981; Calkins and Pitcher 1982). These juveniles were marked on Marmot Island, Alaska, and on Cape St. James, British Columbia and were seen on Baranoff Island, and Cape St. Elias, Alaska, respectively.

Off California and Oregon, adult males are uncommon in winter, and are believed to migrate north to British Columbia and Alaska (Bartholomew and Boolootian 1960; Mate 1975). Evidence for this movement comes from Scammon (1874) who recovered a spear-head, made by Alaskan natives, from the carcass of a male Steller sea lion taken off California in June 1870. In addition, Mate (1975) observed a peak in numbers of adult males off Oregon during May and August. These peaks are believed to represent the southern and northerly migration of animals between California and sites north of Oregon. No rookeries exist in Washington.

As in Alaska, local dispersion appears to take place after breeding in British Columbia, with some immigration and emigration likely. Seasonal changes in distribution are evident when the numbers seen at rookeries, year-round haulouts, and winter sites are compared between summer and winter (Table 7). In July, most animals were on rookeries, and few on winter sites, whereas in December the reverse was true. Movements appeared to be mainly between rookeries and winter sites. Numbers on year-round haulouts did not vary much between July and December. Other data support the view that local movements exist. Departures from rookeries began in late July, and arrivals on to winter sites began in August, while departures were complete from winter haulouts by late May and arrivals on rookeries began in May. Also, an examination of year-round haulouts and winter haulouts for the occurrence of young-of-the-year, as listed in Bigg (1984), suggests that young dispersed along the coast after the breeding season. By December and January young were seen throughout coastal British Columbia, on most year-round haulouts and exposed winter haulouts. The distribution of young indicates that some movement exists between rookeries and year-round haulouts. A few cows with young were seen on rookeries through until April suggesting that they may not move off the rookery after the breeding season. Gentry (1968, 1970) also reported some cows and young at Año Nuevo Island, California, during winter.

TABLE 7. Comparison of average number of Steller sea lions seen on rookeries, year-round haulouts, and winter sites in British Columbia in summer and winter during 1971–82. Data from Tables 2, 5, and 6.

Site	December 1971–76	July 1971–82
Rookeries	960 (15%)	3 872 (65%)
Year-round haulouts	1 527 (24%)	1 919 (32%)
Winter sites	3 812 (61%)	206 (3%)
Total	6 299	5 997

The total number of Steller sea lions seen in British Columbia was larger in winter than in summer. The difference was larger than indicated in Table 7, in that the counts during winter were more likely to have been underestimates than counts in summer. Yet, if all seasonal movements took place only within British Columbia, then the counts in winter should be smaller than those in summer as some natural mortality would take place between summer and winter. Assuming that the same proportion hauled out in winter as in summer, some immigration seems likely. Immigration of adult and subadult males could come from California and Oregon, as has long been suspected. Support for this possibility comes from the fact that I observed only adult and subadult males off southern Vancouver Island, at Race Rocks, Plumper Sound, and Ada Island. C. Brenton (Parksville, Vancouver Island, pers. comm.) reported that he saw very few adult females during observations in winter at Folger Island. Some immigration could have come from Forrester Island, Alaska, where few sea lions were present in winter (Table 2). Less immigration probably comes from the more northern rookeries in Alaska. The closest is located in Prince William Sound, 1 000 km to the northwest (Calkins and Pitcher 1982; Loughlin et al. 1984). Considering that juvenile dispersion can be extensive, some emigration no doubt exists.

Trends in Numbers Seen

British Columbia

The number of Steller sea lions in British Columbia apparently increased during the late 1800's and early 1900's. Newcombe et al. (1918) stated that fishermen felt sea lions were more numerous in 1913 than in the late 1800's. The growing numbers stimulated the census in 1913, and the control programs. This increase may have resulted from a recovery of the population after depletion by natives for meat, hides, oil, and other products (Newcombe and Newcombe 1914; Wailes and Newcombe 1929). The Alaska Department of Fish and Game (1973) reported the species in Alaska was reduced prior to 1900 for the same reason. If natives did deplete the population in British Columbia, then the numbers of sea lions would have been low during the early 1800's, when the number of Indians was relatively high, at about 70 000 (Duff 1977). By 1885, epidemics had reduced their numbers to only 28 000. Utilization of sea lions also decreased through the 1800's, with few Indians in British Columbia relying on them by the early 1900's.

The changes in population size in British Columbia after 1913 can be traced using the two indices: total number of pups and nonpups seen on rookeries, and total number of pups born. Newcombe and Newcombe (1914) estimated the total number of pups and nonpups seen on rookeries to be about 9 300 in 1913. Newcombe et al. (1918) reported it to be larger, about 9 800 in 1916, despite a control program during the intervening years. The similarity in the results of these two censuses appears to be coincidental. In fact, they were neither comparable in timing, nor in degree of preceding harassment. Counts at Beresford Island, Virgin Rocks, and Cape St. James in 1913 were made before or after maximum numbers were ashore in July. Harassment preceded the counts on Beresford Island in 1913, and probably on Cape St. James in 1916. Based on an examination of the most reliable counts of pups and nonpups on each rookery during 1913 and 1916, I estimate the total number of animals seen on rookeries during 1913 was probably closer to 14 000 pups and nonpups. The census in 1913 was best for Triangle Island, Pearl Rocks, Watch Rock, and Cape St. James. These sites had a total of about 4 400 animals. The census in 1916 was best for Beresford Island and Virgin Rocks. These had about 8 700 sea lions. The number present on the latter rookeries in 1913 may not have been much larger than during 1916 despite the fact that more than 4 600 animals were killed there during 1913–15. Up to 75% may have been pups. Also, some annual recruitment of nonpups from nonrookery areas probably occurred, which would replace some animals killed. Added to the total number seen were 1 000 animals probably present on North Danger Rocks. Alternatively, if one ignored the potential effects of harassment and of seasonal timing of censuses, but incorporated a correction for extra pups born and the likely number on North Danger Rocks, then the population on rookeries numbered at least 11 000 in 1913 (Table 2). The range was thus 11 000–14 000.

By 1938, rookeries of the Sea Otter Group were

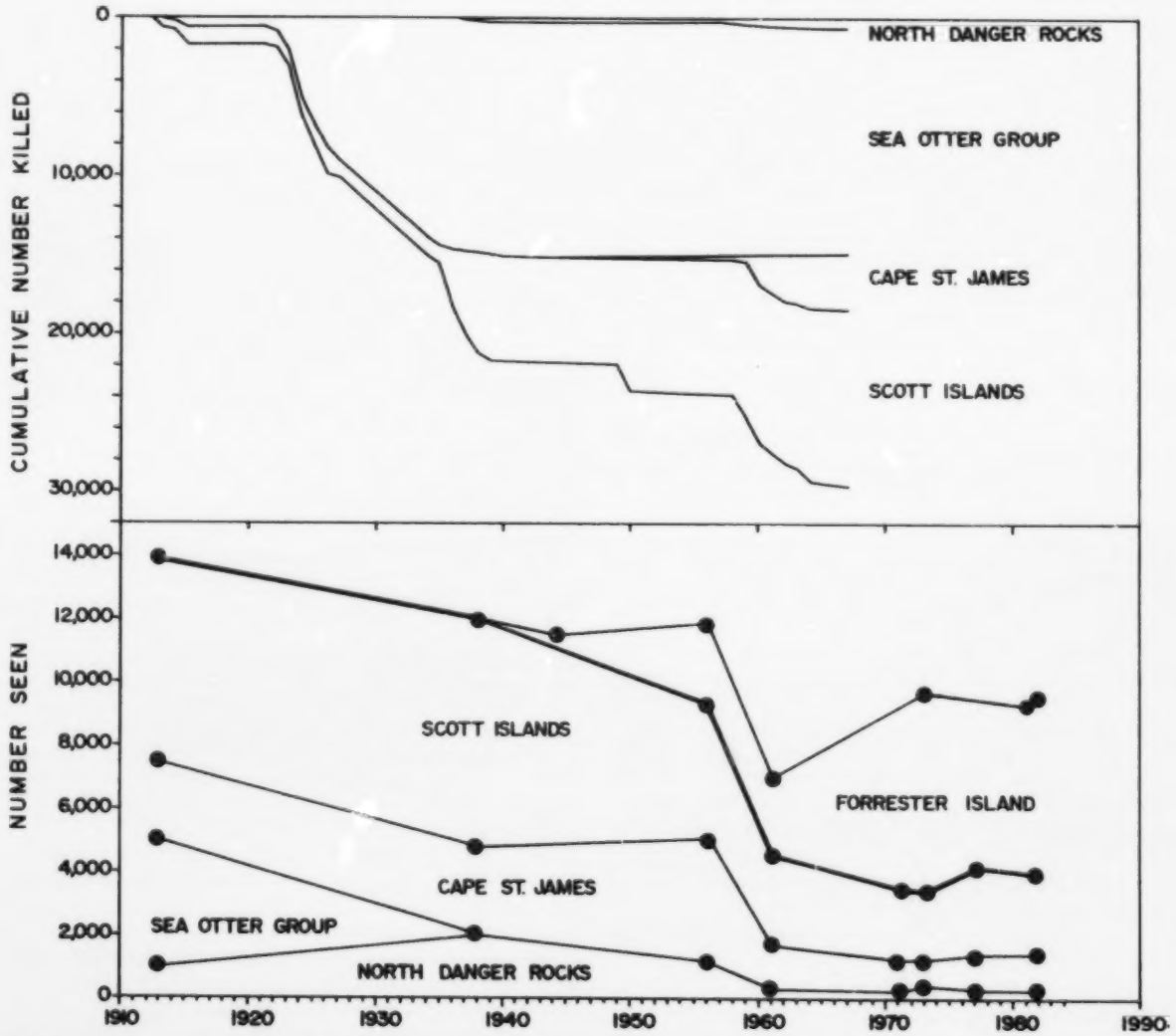

FIG. 8. Total number of pups and nonpups of Steller sea lions seen on rookery groupings in British Columbia, and on Forrester Island, Alaska, during 1913–82, and the cumulative number of nonpups killed in British Columbia. Kills on the Sea Otter Group were assumed to consist of 75% pups. Data from text and Tables 2 and 3.

essentially eliminated through intensive annual kills since 1922 (Fig. 8). Countering this decline were increases on the Scott Islands, at Triangle Island and Sartine Island, although a decrease took place on Beresford Island. Assuming that the 4 000 sea lions seen on the Virgin Rocks in August 1938 originated from the Scott Islands, the Scott Island rookeries would have contained about 7 200 animals in 1938. The total number of animals seen in British Columbia during 1938 was similar to that in 1913. However, as the census in 1938 followed reported kills of 7 900 sea lions (2 400 pups) in 1936–38 on the Scott Islands, the rookeries of the Scott Islands must have increased between 1913 and 1936. Thus, the total number of animals on rookeries in British Columbia could have increased by several thousand between 1913 and 1936, despite the elimination of most animals on the rookeries of the Sea Otter Group.

No kills for management or commercial purposes took place on rookeries between 1940 and 1956, except for one kill on the Scott Islands in 1950. However, the Canadian airforce and navy apparently made substantial kills during the 1940's. By 1956, the total population seen on rookeries in British Columbia had decreased. The decrease could have resulted from: the elimination of rookeries on the Sea Otter Group where no recovery was possible; the lack of time for recovery by the population on the Scott Islands following the large kills of 1936–39 and 1950; and from kills by military personnel during the 1940's. After 1956, large kills continued on the Scott Islands, North Danger Rocks, and Cape St. James. This resulted in a further decrease in total numbers seen by 1961. Subsequent kills brought still more reductions on all rookery groupings to relatively low, but stable numbers by 1971–82. Based on the total number of pups and nonpups seen on rookeries, only about 27-34% of the population estimated to have been seen in 1913 was present by 1971–82.

Interestingly, much of the reduction observed on rookeries in British Columbia was replaced with increases on Forrester Island. The growth of the stock at Forrester Island could have filled the niche vacated by the extinct rookeries at the Sea Otter Group and the reduced size of the remaining rookeries in British Columbia. Such being the case, the population on Forrester Island could be included with the rookeries in British Columbia, as part of a larger regional sea lion population. The total number present in the region during 1971–82 would then be only about 67–86% of the level in 1913. The total number of pups and nonpups seen in British Columbia during 1971–82 compares with the following recent total counts for the species seen elsewhere in the North Pacific Ocean: 28,300 off the USSR, 196,500 off Alaska, 1,000 off Washington, 2,300 off Oregon, and 3,000 off California (Loughlin et al. 1984).

Based on the second index, the number of pups born, the British Columbia stock probably declined a similar amount to that indicated by the total number of pups and nonpups seen on rookeries. Unfortunately, little attention was paid to the counting of pups in 1913–16, and none in 1938. However, early pup production was likely to be at least as large as that seen in 1956. Thus, by 1971–82, pup production probably declined to 35%, or less, of that in 1913. If the number of pups currently born on Forrester Island was included with those on rookeries in British Columbia, then the regional stock may have actually increased by 5% since 1956. During 1971–82, about twice as many pups were born on Forrester Island as on all rookeries combined in British Columbia (Table 2).

A comparison of annual changes in the production of pups in British Columbia during 1971–82 suggests that an increase in breeding stock may have occurred between 1977 and 1982 (Table 2). However, with no increase in the number of nonpups seen during this time, the increase in numbers of pups seen in 1982 may be indicative only of better survival of pups in 1982 than usual, and not a true increase in size of the breeding stock.

Few data exist on the change in numbers that may have taken place at year-round haulouts since 1913. During June–August 1913, Newcombe and Newcombe (1914) visited only Isnor Rock, where 18 sea lions were seen, and Solander Island, where none was seen. Nonetheless, based on conversations with Indians and fishermen, Newcombe and Newcombe (1914) felt that perhaps 1 700 animals were present on nonbreeding sites in summer. Later, Newcombe et al. (1918) suggested the number was much larger, as high as 10 000 animals. This figure was not based on direct evidence of more animals seen. It was largely a guess used to explain the lack of an observed decline in the population between 1913 and 1916, and the apparent variability in the number of animals hauled out on Cape St. James in 1913 and 1916. The current study suggests that this reasoning was not correct, and hence the number may have been closer to the estimate given for 1913. Insufficient counts were made during summer to indicate whether the number present on year-round haulouts was larger prior to 1956.

The total size of the British Columbia stock can be estimated from the number of pups born. Calkins and Pitcher (1982) calculated the total number of pups and nonpups present at the end of the pupping season in Alaska to average about 4.5 times the number of pups born. Assuming this to be the case in British Columbia, then the stock in 1956 consisted of 14 625 animals. This number was larger than the 11 300 estimated to have been seen on rookeries and year-round haulouts (1900) at that time (Table 2, 5). The extra animals could have been at sea feeding, and dispersed to coastal areas outside of British Columbia. Using the same multiple, the size of the stock in 1971–82 was 5 100 animals. But this figure was about 600 less than that seen on rookeries and year-round haulouts in summer during these years. The closer correlation between the number observed and expected could reflect an increased accuracy of current censusing methods or an increase in the number of sea lions originating from Forrester Island.

The counts on rookeries during summer 1971–82 in British Columbia indicate a lack of recovery of the population following the end of the control programs in the mid 1960's. An increase in the number of pups was expected for the depeleted rookeries, perhaps at the rate of 7%/yr, as found on Forrester Island between 1961 and 1973. Several reasons are possible for the lack of recovery. One may be that the recent large growth of rookeries on nearby Forrester Island inhibited the recovery of stocks in British Columbia. The stocks from British Columbia and Forrester Island probably mix at some time during the

TABLE 8. Number of Steller sea lions seen off southeastern Vancouver Island during 1972–84.

	1972	1973	1977	1978	1982	1984
	25 Feb.	25 Jan.	7–9 Feb.	9 Feb.	17–22 Feb.	15–16 Feb.
Race Rocks	71	45	68	139	53	22
Plumper Sound area	0	0	286	115	294	23
Porlier Pass area	0	0	0	0	105	112
Ada Island	0	40	211	351	163	139
Denman Island	0	0	0	0	324	0
Other	0	0	0	15	43	32
Total	71	85	565	622	983	328

year, and thus could compete for food. If this is the case, the population in British Columbia will not exhibit a marked recovery in the future to the levels recorded during 1913–1956. Based on the number of pups and nonpups in British Columbia and at Forrester Island, the size of the current regional population may not be much below that seen during 1913–56, and thus perhaps is near the carrying capacity. Another possibility is that no obvious cause for the lack of recovery may be evident. Braham et al (1980) showed the total number of animals in the eastern Aleutian Islands declined unexplainably from about 50 000 in the late 1950's to about 25 000 in 1977. Shifts in distribution, disease (Leptospirosis), and increased commercial fishing were considered. Loughlin et al. (1984) examined trends in numbers of this species throughout it's range, and concluded that total numbers did not change between 1956 and 1980. However, these authors suggest that some regional shift in numbers appears to have taken place in Alaska, perhaps due to animal displacement, or seasonal movements. Alternatively, Fowler (1982) studied the recent lower than expected productivity of northern fur seals in the eastern North Pacific. He showed one likely cause for the decline was an increase in natural mortality due to an increase in the rate of entanglement in synthetic scrap fishnet and plastic packing bands. A minimum of 5% of northern fur seals now die per year from this cause. We have also seen Steller sea lions in British Columbia with this kind of debris around their necks, and so this could be a factor. Another obvious possibility is that increased commercial fishing has reduced the food supply for the species, and this resulted in a reduced carrying capacity.

Southeastern Vancouver Island

Our censuses during 1972–84 (Table 8) confirm the observations of fishermen that the number of Steller sea lions increased recently during winter off southeastern Vancouver Island, although a decrease has now taken place. Beginning in about 1972–73, the species increased in numbers throughout southeastern Vancouver Island. This can be illustrated by the occupation of progressively more haulouts. For example, the species was seen regularly for the first time at Ada Island and Trail Islands in 1973, at Plumper Sound in 1977, at Sand Heads in 1978, Denman Island in 1979, and Porlier Pass in 1982. The number of animals increased progressively between 1972 and 1982. The trend of increasing numbers during the 1970's was also indicated from daily counts at two haulouts. Some animals at these sites were hidden from view, and so the numbers given are indicative mainly of trends rather than absolute numbers. Sea lions were not seen at Race Rocks up to the early 1960's (Fig. 9). A few animals were present by the mid 1960's, and numbers increased through to 1978, reaching a peak of 250 animals. At Ada Island, numbers increased up to the 1978, reached a peak of about 400 animals, and remained at fairly stable level up to 1982 (Fig. 10). However, between 1982 and 1984 a sharp decline took place off southeastern Vancouver Island with the main decreases at Denman Island and Plumper Sound (Table 8).

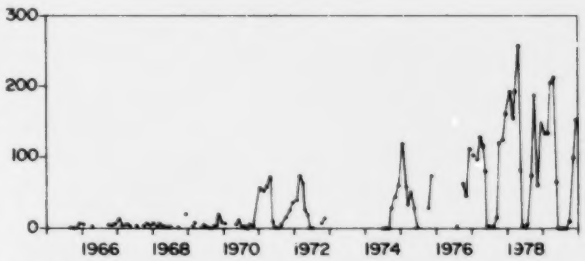

FIG. 9. Monthly maximum number of Steller sea lions seen at Race Rocks during 1965–79 as recorded mainly by T. Anderson.

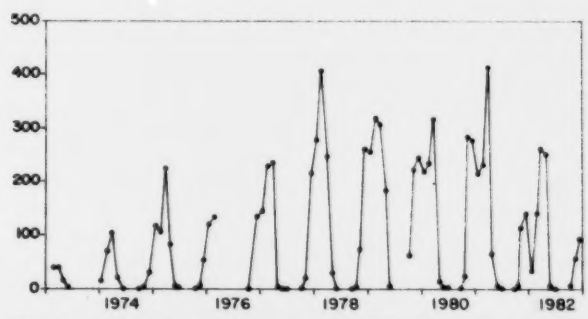

FIG. 10. Monthly maximum number of Steller sea lions seen at Ada Island by I. MacAskie during 1973–82.

The yearly changes in numbers of animals seen off southeastern Vancouver Island were due to shifts in the distribution of wintering animals. The changes did not mirror variations in the size of populations at rookeries in British Columbia, at Forrester Island, or at rookeries off Oregon, and California (B. Mate, Oregon State University, Newport, pers. comm.; Le Boeuf and Bonnell 1980; Loughlin et al. 1984). The increase in numbers during 1972–82 could have been caused by an increase in local food supply. Studies of diet from an examination of scats indicate that herring is the most important prey for Steller sea lions off southeastern Vancouver Island (P. Olesiuk, Fisheries Research Branch, Department of Fisheries and Oceans, Nanaimo, pers. comm.). This sea lion is also reported to feed extensively on herring during winter in sheltered areas elsewhere in British Columbia (Newcombe et al. 1918; Spalding 1964). Stocks of herring off southeastern Vancouver Island were severely depleted by over fishing during the late 1960's, but had recovered by the mid 1970's (Hourston 1980). An alternate explanation, or at least a contributing factor, for an increase during 1972–82, may be that the control programs kept many animals away up to the late 1960's. The species was frequently hunted in this populated region. With protection in 1970, harassment ceased and sea lions could have returned. Certainly the species now hauls out at many sites where they were not known to do so previously during this century, such as at Ada Island, Trail Islands, Sand Heads, and Race Rocks.

The main decreases in the number of Steller sea lions off southeastern Vancouver Island between 1982 and 1984 were at sites that were important spawning grounds for herring. Relatively few herring were present at Denman Island and Plumper Sound during February 1984 (R. Armstrong, Field Services Branch, Department of Fisheries and Oceans, Nanaimo, pers. comm.). The lack of food may have driven the animals elsewhere. As the number at other sites off southeastern Vancouver Island did not change, animals must have been displaced outside this region. Another possible reason for the decrease is that the Steller sea lion experienced increased competition for food from California sea lions. California sea lions recently increased off southeastern Vancouver Island during winter from about 50 in 1972 to about 1 700 by 1984. In either case, the current size of the Steller sea lion population there is probably closer to that prior to the 1970's, based on the few earlier sighting records available (Bigg 1984), than that seen in 1982.

California Sea Lions

Distribution

The main distribution of California sea lions in British Columbia is Vancouver Island, from the Barkley Sound area southward to Race Rocks, and northward to Denman Island (Fig. 11). A few also occur at Solander

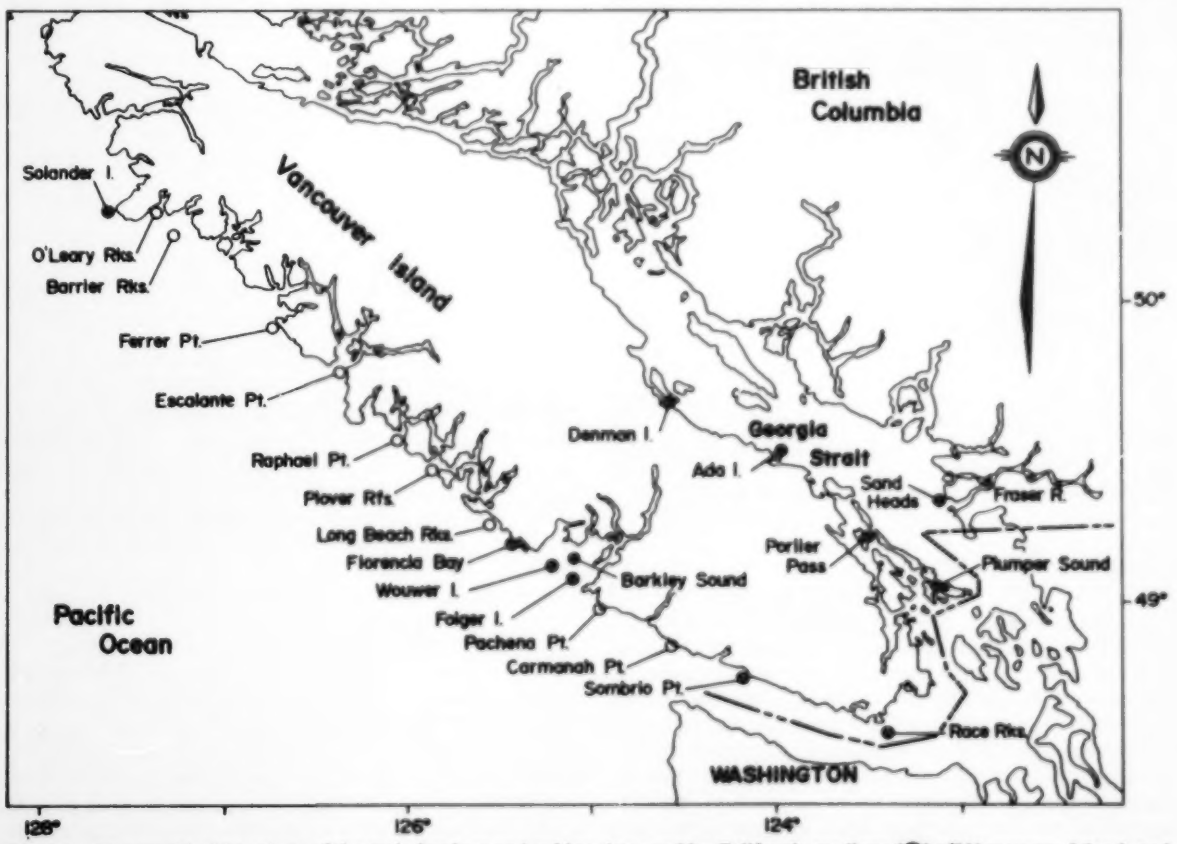

FIG. 11. Geographical locations of the main haulout and rafting sites used by California sea lions (●) off Vancouver Island, and sites used only by Steller sea lions (○).

Island. The sites at which this species congregates are winter haulouts and rafting areas, as described for Steller sea lions. Rafting occurs mainly in the area of Porlier Pass and Plumper Sound. In the late 1960's, the species was found regularly only in small numbers in Barkley Sound, and at Race Rocks (Hancock 1970; Guiguet 1971). During the 1970's, the distribution extended gradually into southeastern Vancouver Island with the main concentration eventually being in the vicinity of Plumper Sound and Porlier Pass. The colonization sequence into southeastern Vancouver Island was as follows: Porlier Pass in 1972, Ada Island in 1973, Sand Heads in 1978, and Denman Island in 1979. By 1973, the range extended north of Barkley Sound to Solander Island. Occasionally, 1–7 individuals were seen at more northerly sites in British Columbia, such as Triangle Island, Cape St. James, and Joseph Rocks. Small numbers (<100) were found also in eastern Washington, at Sucia Island and Port Gardner (Everitt et al. 1980; Bigg 1984).

Off southeastern Vancouver Island, California sea lions were usually seen at sites with Steller sea lions. However, off western Vancouver Island, California sea lions were at only a few sites occupied by Steller sea lions. During numerous censuses in winter between Race Rocks and Solander Island, California sea lions were rarely found at Carmanah Pt., Pachena Pt., Long Beach Rocks, Plover Reefs, Raphael Pt., Escalante Pt., Ferrer Pt., Barrier Rocks, and O'Leary Rocks (Fig. 11). These sites were occupied by typically 50–250 Steller sea lions in winter. California sea lions appeared to avoid sites that were exposed directly to oceanic swells. Large swells do not occur off southeastern Vancouver Island, but do off western Vancouver Island where they can be large, particularly in winter. Sites occupied by California sea lions off western Vancouver Island tended to be on the leeward side of islands. Individuals were often seen in ravines, and sometimes even at the base of trees and shrubs, where Steller sea lions were not typically seen.

Movements

Hancock (1970) cited an observation by lighthouse keeper T. Anderson during the 1960's that California sea lions arrived at Race Rocks in late October, reached a peak in numbers in February, and departed by May. Daily counts made in 1971 by the same lighthouse keeper (Fig. 12) suggest a slightly different movement schedule than the earlier report. Arrivals began in September, and departures were completed by late May. No animals were present between June and August. A distinctive peak in numbers did not occur in February, although the month with peak numbers was not clear in 1971 due to the small number of observations made in December. Based on *the mean and maximum numbers* seen during 1971, most animals had arrived by November. Anderson made daily counts during other years between 1967 and 1979 (Bigg 1984) which, while less complete, indicated basically the same arrival and departure schedule.

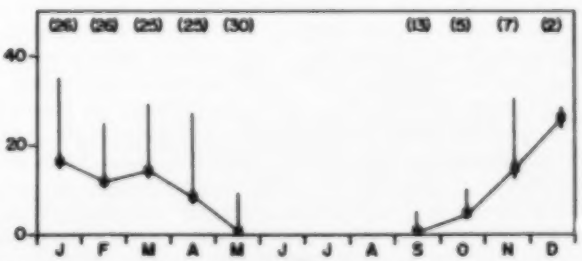

FIG. 12. Monthly mean, standard error of the mean, and maximum number of California sea lions counted at Race Rocks by T. Anderson during 1971. Number of days of observation shown in parentheses.

An inspection of numerous sitings of California sea lions in Georgia Strait, as given in Bigg (1984), indicated arrival in this more easterly area occurred slightly later than at Race Rocks, during October–November. The same movement schedule as described for Steller sea lions was seen for up to 265 animals of this species at Sand Heads. Records from lighthouse keepers and fishery officers during 1978–82 indicated that arrivals began in mid March, numbers reached a peak in late April–early May, and departures were completed by late May. The site was used by this species, along with the Steller sea lion, apparently to feed on eulachon that spawn in the nearby Fraser River at this time. Also, in late April 1984, a fishery officer saw about 120 California sea lions 50 km up the Fraser River.

The observed time of arrival of California sea lions off southern Vancouver Island coincided with the predicted schedule, based on movement patterns recorded in more southern locations. After breeding in May–June off California and Mexico, females remain south of central California, while males migrate northward (Peterson and Bartholomew 1967; Orr and Poulter 1965; Morejohn 1968). Mate (1975) plotted the northward migration of males between California and British Columbia. Using the observations of Mate, the main arrival time of males at Race Rocks should be November, as indicated in the current study. Also as expected, I observed only adult and subadult males at Folger Island, Race Rocks, Ada Island, and Sand Heads, and Hancock (1970) reported only males at Race Rocks.

Trends in Numbers Seen

During the early 1900's, the number of California sea lions in British Columbia was very low, and increased noticeably only in recent years. Newcombe and Newcombe (1914) and Newcombe et al. (1918) did not observe the species, but did cite accounts of it in Barkley Sound during the late 1800's and early 1900's. However, so uncertain was the evidence for occurrence that Wailes and Newcombe (1929) later stated no proof existed for the species in British Columbia. Guiguet (1953) established proof of early presence with the discovery of a skull collected just north of Barkley Sound in the late 1800's. He also reported small numbers seen by fishermen in Barkley Sound during winter in the mid 1950's, and noted an apparent increase in numbers during the 1960's (Guiguet 1971). The Canadian Department of Fisheries and Oceans undertook extensive surveys for sea lions during winter in the 1950's and 1960's, and reported only a few California sea lions were observed, all in the vicinity of Barkley Sound. By the late 1960's, a small colony had formed at Race Rocks

TABLE 9. Number of California sea lions seen off Vancouver Island during 1972–84.

	1972 25 Feb.	1973 25 Jan.	1977 7–9 Feb.	1978 9 Feb.	1982 17–22 Feb.	1984 15–16 Feb.
SE Vancouver Island						
Race Rocks	35	38	70	13	320	799
Plumper Sound area	0	0	10	30	220	53
Porlier Pass area	10	0	0	0	418	764
Ada Island	0	0	29	58	39	84
Denman Island	0	0	0	0	20	0
Other	0	0	0	0	4	2
Subtotal	45	38	109	101	1 021	1 702
SW Vancouver Island						
Sombrio Pt	1	—	16[b]	—	—	93
Folger Island	387	0	152[b]	—	12	0
Wouwer Island	40	—	8[b]	—	415	839
Florencia Bay	—	—	—	—	+	1 777
Solander Island	0[a]	33	40[b]	—	—	50
Other	0	0	2[b]	—	72	35
Subtotal	428		218		499+	2 794
Total	473		327		1 520+	4 496

[a] 7 Dec. 1971.
[b] 13 Dec. 1976.

(Hancock 1970), and up to 300 were reported in Barkley Sound in the winter of 1970–71 (Hatler 1972). In 1972, a colony of 400 was found at Folger Island (Bigg 1973). Censuses off Vancouver Island during 1972–84 suggest that numbers increased slightly between 1972 and 1978, but increased sharply by 1982, and again by 1984 (Table 9).

The main increase in numbers off southeastern Vancouver Island took place at Race Rocks, Plumper Sound, and Porlier Pass. As with Steller sea lions, a decrease in the number of California sea lions was seen at Plumper Sound between 1982 and 1984, presumably also due to reduced stocks of herring. However, herring remained numerous at Porlier Pass during this time, as did this sea lion. Confirmation of the trend in increasing numbers of California sea lions during the 1970's is given from daily counts taken at Race Rocks during 1965–79 (Fig. 13). The species was not present before the mid 1960's. Between 1970 and 1979, the number of animals progressively increased.

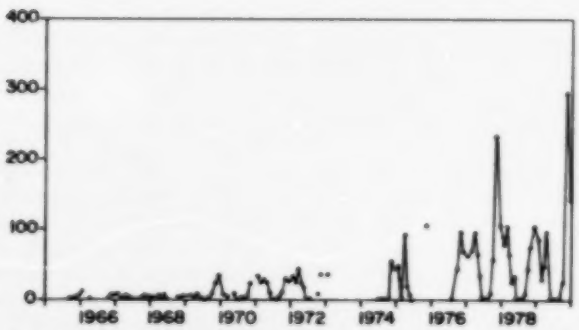

FIG. 13. Monthly maximum number of California sea lions seen at Race Rocks during 1965–79 recorded mainly by T. Anderson.

Counts at sites off western Vancouver Island were not as complete during each survey as those off southeastern Vancouver Island, and the counts were not always comparable in timing between years. An important site missed until 1984 was Florencia Bay. In 1984, it had the largest number of California sea lions present of any site off Vancouver Island. Information on the history of sea lions at this site comes from observations by D. Girodet (Field Services Branch, Department of Fisheries and Oceans, Port Alberni, pers. comm.). During annual aerial surveys for herring in winter, he noted only 10–20 sea lions were present on this haulout during 1975–79. Beginning in 1980, he observed that "hundreds" were present.

The number of California sea lions off Vancouver Island increased 10-fold between 1972 and 1984, with most of the increase apparently taking place since 1980. The species did not increase the northern range in association with the sharp increase in numbers since the late 1970's. None was seen during an aerial survey for Steller sea lions around northern Vancouver Island, from Denman Island to Solander Island, during 7 March 1984. Presumably, not all individuals present off Vancouver Island were counted. Some may have been at sea feeding or swimming between sites. The censuses hence provided an estimate of minimum numbers, and annual trends.

An increase in the number of California sea lions off Vancouver Island was expected over the past 50 years, because the breeding population off California has grown steadily. Only about 400–1 000 California sea lions were seen off southern California during the early 1930's, following severe depletion for commercial purposes (Bonnot 1928; Bartholomew and Boolootian 1960). Thus, few animals could have migrated into southern British Columbia early in this century. By 1975, the population off southern California had increased to at least 27 000

(Mate 1977), and since then has continued to increase at a rate of about 5%/yr (DeMaster et al. 1982).

The increase observed off Vancouver Island during the 1980's was much larger than the annual rate of increment for the breeding population off California. Hence, a sudden shift to a more northern migration appears to have occurred in the southern population. One possible explanation is that the population in wintering areas south of British Columbia grew past a critical level of crowding or competition for food and as a result suddenly some males shifted their winter distribution northward. DeMaster et al. (1982) suggested growth of the breeding stock may be slowing due to density dependent factors. Perhaps in approaching maximal numbers, the population expanded the use of the northern range. If this explanation is correct, then the size of the population in British Columbia can be expected to remain large, or perhaps continue to increase in the future if the breeding population off California continues to increase in size. Another possibility is that recent increases in coastal water temperatures encouraged the species to move more northward. Bartholomew (1967) suggested that the northern limit of the breeding range of the species was restricted to southern California by warmwater distribution. In 1982–83, the El Niño current caused a more northly flow of warm water from tropical areas to the coast of British Columbia (Tabata 1984). A longer warming trend also took place along coastal waters of British Columbia between about 1972 and 1981 (Dodimead 1984). Temperature could influence the winter distribution of California sea lions through changes in food supply, or changes in the metabolic costs of thermoregulation. If increased water temperatures caused the numbers of this species to increase in British Columbia, then numbers should decrease over the next few years. El Niño is now diminishing, and a decreasing trend in the long-term temperature of coatal waters is expected.

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References

ALASKA DEPARTMENT OF FISH AND GAME. 1973. Alaska's wildlife and habitat. Anchorage, Ak. 143 p.

BARTHOLOMEW, G. A. 1967. Seal and sea lion populations of the California Islands, p. 229–244. *In* R. M. Philbrick [ed]. Proceedings of the Symposium on the biology of the California Islands. Santa Barbara Botanic Garden. Santa Barbara, CA. 363 p.

BARTHOLOMEW, G. A., AND R. A. BOOLOOTIAN. 1960. Numbers and population structure of the pinnipeds on the California Channel Islands. J. Mammal. 41: 366–375.

BIGG, M. A. 1973. Census of California sea lions on southern Vancouver Island, British Columbia. J. Mammal. 54: 285–287.

1984. Sighting and kill data of Steller sea lions (*Eumetopias jubatus*) and California sea lions (*Zalophus californianus*) from British Columbia during 1892–1982, with some records from Washington and southeastern Alaska. Can. Data Rep. Fish. Aquat. Sci. 460: 191 p.

BONNOT, P. 1928. Report on the seals and sea lions of California. Fish. Bull. No. 14: 61 p.

BRAHAM, H. W., R. D. EVERITT, AND D. J. RUGH. 1980. Northern sea lion decline in the eastern Aleutian Islands. J. Wildl. Manage. 44: 25–33.

BRENTON, C. M. 1977. Inter and intraspecific behaviour of *Eumetopias jubatus* and *Zalophus californianus* on a winter haulout area. M.Sc. thesis, Univ. British Columbia, Vancouver, B.C. 131 p.

CALKINS, D. G., AND K. W. PITCHER. 1982. Population assessment, ecology and trophic relationships of Steller sea lions in the Gulf of Alaska. U.S. Dep. Int., Bur. Land Manage., Outer Continental Shelf Environ. Assess. Progr. Final Rep., Res. Unit 243 Contract 03-5-022-69: 129 p.

DEMASTER, D. P., D. J. MILLER, D. GOODMAN, R. L. DELONG, AND B. S. STEWART. 1982. Assessment of California sea lion fishery interactions. Trans. 47th N. Am. Wildl. Conf. p. 253–264.

DODIMEAD, A. J. 1984. A review of some aspects of the physical oceanography of the continental shelf and slope waters of the west coast of Vancouver Island, British Columbia. Can. MS Rep. Fish. Aquat. Sci. 1773: 309 p.

DUFF, W. 1977. The Indian history of British Columbia. Volume 1. The impact of the White man. Anthropology in British Columbia. Memoir No. 5. British Columbia Provincial Museum, Victoria, B.C. 117 p.

EDIE, A. G. 1977. Distribution and movements of Steller sea lion cows (*Eumetopias jubata*) on a pupping colony. M.Sc. thesis, Univ. British Columbia, Vancouver, B.C. 81 p.

EVERITT, R. D., C. H. FISCUS, AND R. L. DELONG. 1980. Northern Puget Sound marine mammals. Interagency Energy/Environment R. and D. Progr. Rep., U.S. Environ. Prot. Agency: EPA-600/7-80-139. 135 p.

EVERMANN, B. W., AND C. D. HANNA. 1925. The Steller sea lion rookery on Año Nuevo Island, California in 1924. J. Mammal. 6: 96–99.

FISHER, H. D. 1981. Studies on the biology of sea lions in British Columbia. Nat. Geographic Soc. Res. Rep. 13: 215–219.

FOWLER, C. 1982. Interactions of northern fur seals and commercial fisheries. Trans. 47th N. Am. Wildl. Nat. Res. Conf. p. 278–292.

GENTRY, R. L. 1968. Social behavior of the Steller sea lion, p. 21–25. *In* Año Nuevo Rep. Vol. 2, 1967–68. University of California, Santa Cruz, CA. 79 p.

1970. Social behavior of the Steller sea lion. Ph.D. thesis, Univ. California, Santa Cruz, CA. 113 p.

GUIGUET, C. J. 1953. California sea lion in British Columbia. Can. Field Nat. 67: 140.

1971. An apparent increase in California sea lion, *Zalophus californianus* (Lesson) and elephant seal, *Mirounga angustirostris* (Gill), on the coast of British Columbia. Syesis 4: 263.

HANCOCK, D. 1970. California sea lion as a regular winter visitant off the British Columbia coast. J. Mammal. 51: 614 p.

HARESTAD, A. S. 1977. Seasonal abundance of northern sea lions, *Eumetopias jubatus* (Schreber) at McInnes Island, British Columbia. Syesis 10: 173–175.

HARESTAD, A. S., AND H. D. FISHER. 1975. Social behavior in a non-pupping colony of Steller sea lions (*Eumetopias jubata*). Can. J. Zool. 53: 1596–1613.

HATLER, D. 1972. The mammals of the Pacific Rim Park. National and Historic Parks Branch, Western Region, Calgary, Alta. 223 p. (Unpublished report)

HOURSTON, A. S. 1980. The decline and recovery of Canada's Pacific herring stocks. Rapp. P.-V. Reun. Cons. Int. Explor. Mer 177: 143-153.

IMLER, R. H., AND H. R. SARBER. 1947. Harbor seals and sea lions in Alaska. U.S. Fish Wildl. Serv. Spec. Sci. Rep. 28: 22 p.

KENYON, K. W., AND F. WILKE. 1953. Migration of the northern fur seal, *Callorhinus ursinus*. J. Mammal. 34: 86-98.

KING, J. E. 1983. Seals of the world. British Museum (Natural History), and Oxford Univ. Press. 240 p.

LOUGHLIN, T. R., D. J. RUGH, AND C. H. FISCUS. 1984. Northern sea lion distribution and abundance: 1956-80. J. Wildl. Manage. 48(3): 729-740.

LE BOEUF, B. J., AND M. L. BONNELL. 1980. Pinnipeds of the California Channel Islands: Abundance and distribution, p. 475-496. *In* D. Power [ed.]. The California Islands: Proceedings of a multidisciplinary symposium. Santa Barbara Museum of Nat. Hist., Santa Barbara, CA. 787 p.

MATE, B. R. 1975. Annual migrations of the sea lions *Eumetopias jubatus* and *Zalophus californianus* along the Oregon coast. Rapp. P.-V. Réun. Cons. Int. Explor. Mer 169: 455-461.

1977. Aerial censusing of pinnipeds in the eastern Pacific for assessment of population numbers, migratory distributions, rookery stability, breeding effort, and recruitment. Final report to the U.S. Marine Mammal Commission. Report No. MMC-75/01. Reprinted by the U.S. Dep. Comm., Nat. Tech. Inf. Serv. PB-265 859: 67 p.

MATHISEN, O. A., R. T. BAADE, AND R. J. LOPP. 1962. Breeding habits, growth and stomach contents of the Steller sea lion in Alaska. J. Mammal. 43: 464-477.

MATHISEN, O. A., AND R. J. LOPP. 1963. Photographic census of the Steller sea lion herds in Alaska, 1956-58. U.S. Fish and Wildl. Serv., Spec. Sci. Rep. 424: 17 p.

MOREJOHN, G. V. 1968. A northern record of a female California sea lion. J. Mammal. 49: 156.

NEWCOMBE, C. F., W. H. GREENWOOD, AND C. M. FRASER. 1918. Part 1. Preliminary report of the Commission on the sea lion question, 1915. Part 2. Report and conclusion of the sea lion investigation, 1916. Contr. to Canadian Biol. p. 1-39.

NEWCOMBE, C. F., AND W. A. NEWCOMBE. 1914. Sea lions on the coast of British Columbia. Ann. Rep. British Columbia Comm. Fish. for 1913, p. 131-145.

ORR, R. T., AND T. C. POULTER. 1965. The pinniped population of Año Nuevo Island, California. Proc. Calif. Acad. Sci. 32: 377-404.

1967. Some observations on reproduction, growth and social behavior in the Steller sea lion. Proc. Calif. Acad. Sci. 35: 193-226.

PETERSON, R. S. 1968. Social behaviour in pinnipeds with particular reference to the northern fur seal, p. 3-53. *In* R. J. Harrison, R. C. Hubbard, R. S. Peterson, C. E. Rice, and R. J. Schusterman [ed.]. The behavior and physiology of pinnipeds. Appleton-Century-Crofts, New York, NY. 411 p.

PETERSON, R. S., AND G. A. BARTHOLOMEW. 1967. The natural history and behavior of the California sea lion. Am. Soc. Mammal. Spec. Publ. 1: 79 p.

PIKE, G. C. 1961. The northern sea lion in British Columbia. Can. Audubon 23: 1-5.

1966. The northern sea lion, (*Eumetopias jubata*), on the coast of British Columbia. Dep. Fisheries and Oceans, Pacific Biological Station, Nanaimo, B.C. 54 p. (Unpublished manuscript).

PIKE, G. C., AND B. E. MAXWELL. 1958. The abundance and distribution of the northern sea lion (*Eumetopias jubata*) on the coast of British Columbia. J. Fish. Res. Board Can. 15: 5-17.

ROWLEY, J. 1929. Life history of the sea lions on the California coast. J. Mammal. 10: 1-36.

SANDEGREN, F. E. 1970. Breeding and maternal behavior of the Steller sea lion (*Eumetopias jubata*) in Alaska. M.Sc. thesis, Univ. Alaska, College, AK. 138 p.

SCAMMON, C. M. 1874. The marine mammals of the northwestern coast of North America. Dover Publ. Edition (1968). New York, NY. 312 p.

SCHEFFER, V. B. 1958. Seals, sea lions, and walruses, a review of the Pinnipedia. Stanford University Press, London, 179 p.

SMITH, I. D. 1972. Sea lions wintering along the outer coast of Vancouver Island. J. Fish. Res. Board Can. 29: 1764-1766.

SPALDING, D. J. 1964. Comparative feeding habits of the fur seal, sea lion and harbour seal on the British Columbia coast. Bull. Fish. Res. Board Can. 146: 52 p.

TABATA, S. 1984. Anomalously warm water off the Pacific coast of Canada during the 1982-83 El Niño. Tropical Ocean-Atmosphere Newsl. 24: 7-9.

WAILES, G. H., AND W. A. NEWCOMBE. 1929. Sea lions. Museum and Art Notes (Art, Hist., and Sci. Assoc., Vancouver, B.C.) 4: 1-10.

WITHROW, D.E. 1982. Using aerial surveys, ground truth methodology, and haulout behavior to census Steller sea lions, *Eumetopias jubatus*. M.Sc. thesis, Univ. Washington, Seattle. 102 p.